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THE DEVELOPMENT OF ANOPHELES PUNCTIPENNIS SAY.¹

BY MISS CORA A. SMITH.

Anopheles punctipennis Say, is a strictly American form of the so-called malaria mosquito. *A. punctipennis* and *A. maculipennis*, as well as *A. crucians*, have been constantly associated as malaria carriers, especially since Dr. Duprée's discovery of the parasites of malaria in the salivary glands of all three. But in the case of *A. punctipennis* there is growing up a reasonable doubt as to whether in the north it is really a malaria carrier, or at least whether the malaria carried by it is not a different form from that conveyed by *A. maculipennis*. In 1903 Dr. J. B. Smith of New Jersey stated that in that state only *A. maculipennis* had been actually demonstrated to be a malaria carrier; and so far as known this has not been proved to be otherwise. In 1903, also, Hirshberg of Johns Hopkins published the account of his noteworthy inoculations of fifty-eight females of *A. punctipennis*. He allowed them to bite patients afflicted with estivo-autumnal malaria, without finding the parasites in the walls of the stomach, or intestine, in the body cavity, or in the salivary glands. In the opinion of the experimenter himself, however, the fact that out of forty-eight similar inoculations of *A. maculipennis* only eight were infected detracts from the certainty of the results with *A. punctipennis*.

Breeding Places. Larvæ, pupæ, and eggs have been taken from seven different pools near Ithaca, at Forest Home, from October to the middle of August. The people living close by do not have malaria, and on the evidence of reliable citizens, have not had it

¹ This study was carried on in the entomological laboratories of Cornell University under the kindly supervision of Dr. J. G. Needham, to whom I am greatly indebted for constant advice and help.

for at least fifteen years. Whereas, down on the flats at the head of Cayuga Lake, and where *A. maculipennis* is common, there is more or less malaria all the time. Forest Home does not produce *A. maculipennis* at all, while *A. punctipennis* is there in comparatively great numbers. This is not unlike the situation at Baltimore where in 1902 Hirshberg and Dohme reported that "*A. punctipennis* breeds in the higher sections, while *A. maculipennis* is to be found in lower localities."

Local Occurrence. On October 21 a great many full-grown larvæ, also many pupæ, were found in pool 1, which is a drinking place for cattle, fed by a spring, and never dry. It was covered with Lemna, although not densely. A few masses of Spirogyra and Cladophora were there. Larvæ of may-flies, dragon-flies and damsel-flies, various beetles, mostly Dytiscidæ and Hydropphilidæ, great quantities of small crustacea and spring-tails, a great many chironomids of various species, and with some oligochaete worms, a few hydrachnids, and hydras—all these and some other forms, including Culex, were present in the pool. Water-striders and whirligig beetles were very few. The Lemna certainly furnished some food to the larvæ of *A. punctipennis*, for they were often seen to be brushing the leaves, after being brought into the laboratory. The larvæ were found in plentiful numbers, but always in separate groups, as if each had developed from a different laying of eggs.

Pool 2 was of an entirely different character, and about a quarter of a mile away. It was very small, not more than four feet in width at the widest place, and about a foot deep. The bottom was covered with dead leaves, and the water was clear, and there were no visible algæ or other plants in it. It was deeply shaded, and contained just one brood of larvæ, of less than fifty specimens, all of about the same size, and nearly ready to change to the pupa. They were almost black with a white mid-dorsal line. They were the largest larvæ that we have found. None found in the spring were so well developed as these October forms, from which came very large adults.

All the adults developing in autumn are exceedingly hardy. One female emerged from the pupa on November 3, and was left with no food or water. On December 2 it was still alive and eagerly drank water and fed on moistened dates. It lived for three weeks more with access to this food, never having tasted blood, having

spent its whole life in the cage. In the spring and summer they die within three days, under the same treatment of water and food.

A larva of *A. punctipennis* was frozen solid on December 3, was thawed out on December 4, and in an hour was apparently normal.

The full-grown larvæ found in the autumn differed more from one another than those found in the spring and summer, when they are mostly green or brown. In autumn there were many more of the striped and speckled forms. They all developed into *Anopheles punctipennis*, with some differences in size.

Pool 2 did not yield larvæ of *A. punctipennis* in the spring, having dried up completely, and pool 1 was much later in developing them than 3 which was near by—within a hundred feet.

Pool 3 on May 24 yielded larvæ of all sizes. Most of them, however, were ready to pupate. They represented the first laying of the spring. The water of this pool was several feet deep at one end, and clear and cool. No larvæ have been found at this spot, in the shade of an overhanging bank where *Spirogyra* grows deep, giving its clear green hue from below the surface. A few feet away, in shallow water with *Spirogyra* protruding from the surface, were plenty of larvæ. With the *Spirogyra*, and also in fruiting condition, was plenty of *Zygnema*. In and above these mats of fruiting algæ, many of them feeding down among the filaments, were larvæ of *A. punctipennis*, mostly full grown. And with them in great numbers were several species of Chironomid larvæ, weaving their houses of the delicate threads, and feeding there as well. This pool was visited at intervals, until on June 10 there were scarcely any larvæ, but a few pupæ and plenty of empty pupa cases. On June 17, however, great numbers of very small ones from 1 to 2 mm. and less were to be found again in pools 3 and 1. In 1 they were found only among the *Lemna*, and in 3 only in mats of *Spirogyra* and *Zygnema*. Meanwhile, multitudes of toad tadpoles had developed in pool 3, and along with their growth went the disappearance of the mats of algæ from the surface, and also of *Anopheles punctipennis* from that part of the pool. They were found a month later in almost the same place in great numbers among fruiting *Chara*, which had spread from the deeper part of the pool. There was protection and food among its filaments.

Pool 4 was a temporary pool beside Fall Creek, about six feet in length and three feet or less in width. It was sheltered by an overhanging stump, but was in the bright sunlight nearly all day. Pools 3 and 1 were sunny also. The only alga in it was *Mougeotia* which was in vigorous fruiting condition. Embedded within it were many masses of Chironomid eggs, as well as many full-sized Chironomid larvæ within their filmy homes. Many very small larvæ of *A. punctipennis* were at the surface of the water among the delicate filaments. A great many minnows were darting about below the algæ, also small Coleoptera. There were no water-striders or whirligig beetles, or other surface feeders. After two weeks the *Mougeotia* had sunken to the bottom and the larvæ of *A. punctipennis* had disappeared, excepting a few large ones.

Pool 5 was near 4 but in the deep shade, the larvæ being confined to a mat of *Spirogyra*. Here the water flowed slowly. Pool 6 was near, but in sunlight all day, and the larvæ were concentrated among the filaments of a mass of *Mougeotia*, and were to be found nowhere else in the pool. The water flowed quite rapidly by, but the *Mougeotia* was anchored.

All the larvæ found in the *Mougeotia* were exceptionally transparent, even in the older stages. Just after molting, they were almost as clear as glass, and were at all times the best ones to study. On the other hand, larvæ found in pool 7, a muddy dark pool in a very shady place, were always very dark and opaque. Here the larvæ were found among the large floating leaves of a *Polygonum*, and nowhere else in the pool.

Feeding Habits. A number of larvæ of all ages were put in a watch crystal with small masses of *Zygnema* and *Mougeotia*, all in fruiting condition. *Cladophora* was added also. A good deal of surface material was devoured by all the larvæ. The younger ones were more particular in the matter of particles, rejecting a good many. They moved around among the filaments, head bent downward, finding plenty to their liking on the *Cladophora*, as well as on the others. They merely brushed off the particles from the larger filaments. A larva of only 1.5 mm. was seen to swallow a filament of *Zygnema*, and to make an effort to swallow large ones of *Spirogyra*, of which it would merely chew the broken ends. Many small larvæ were seen eating the delicate *Mougeotia*. When the food is merely surface particles the head is turned a

half circle with mouth parts upward, next to the surface film; but when feeding on a filament, usually the mouth parts are underneath and the head is bent downward. When feeding in this position, the antennæ and maxillary palpi are spread wide apart, bristles and hairs all extended. The large lateral bristles, outside the antennæ are held out like a fan, and the six branched hairs on the top of the head are raised, making a complete hedge above the rotating brushes.

If particles of food are scarce in the surface film, the young larvæ bend and run their brushes over their own bodies as far as possible, the limit of their reach being apparent by the Vorticellæ and diatoms clinging to the anterior parts of some unlucky individuals. Naturally these are not so active in their movements as the others.

In eating the filaments they swing the brushes furiously until a filament is brought within reach. Or they dive in among the filaments, head down and brushes rotating. Sometimes they merely crush out the contents of the cells, at least in the case of large zygospores of *Spirogyra*, leaving the empty filaments. In that case they grasp the filament anywhere and run it through the mandibles, swallowing only the green parts. The delicate filaments of *Zygnema* and *Mougeotia* are swallowed entirely, also slender filaments of *Spirogyra*. They show considerable preference for the more delicate filaments. Usually they draw the filament into the mouth with the rotating brushes, bite it in two, and then rapidly draw in one broken end. They rarely leave a filament partly consumed, and often go back to the other broken end.

The food of the larva of *A. punctipennis*, is not necessarily entirely of an herbivorous nature. Once I saw two young water fleas (*Simocephalus*) almost dragged into the abyss. They struggled valiantly and escaped by setting up counter currents with their feet. The three currents could be seen close to one another. One went too near and lost an antenna which was broken and swept in by the brushes. It drew back but was temporarily incapacitated and unable at once to leave the vicinity. Finally, it escaped. A little *Chydorus* all but lost its life, being drawn in by the brushes, but escaped.

Fatalities. Dr. J. B. Smith in his report on the Mosquitoes of New Jersey (1904) gave a detailed account of the enemies of mosquitoes. He remarked that the larva actually faces greater dan-

gers than does the adult. He placed as enemies, first weather conditions; then diseases, of which we know little. We have seen several conditions which relate to this subject, however.

Four young larvæ that had passed their second molting were every one of them afflicted with a protruding intestine, which extended out from the body for fully half the length of the larva. This condition lasted for more than a day after they were taken from the pool. A scarcity of food,—for they were kept in clear water for twenty-four hours—evidently cured them. They were normal on the second day after.

Spirogyra furnishes food for the growing larva, but it also shelters enemies. It is the favorite habitat of several species of chironomids, and in just so far is it a check to mosquito development. The chironomid larvæ build their tubes of the algæ filaments, and seemingly of other things too.

In six different instances we have had evidence that some chironomid larvæ destroy the larva of *Anopheles punctipennis*, and feed upon its tissues, as well as using portions of its body to fill in the crevices of their houses. In all the cases, the *Anopheles* was in the quiescent state just preceding or following the molting process. In one case the chironomid built its tube close up beside the body of the dead *A. punctipennis*, and gradually transferred the tissues into the walls of its home. In another case a chironomid was seen to swallow a part of the dark mass of the dead mosquito larva, and the digestion in the chironomid was watched through the transparent organs. A healthy larva of *A. punctipennis* was supposedly alone in a dish of water with algæ for food. It was left over night. In the morning its head was torn from its body and was floating at a distance. The only living animal in the dish was a chironomid larva.

Development. Careful observations on the swarming of *Anopheles punctipennis* have been reported by Knab (1907). The males were seen to swarm a little before 5 o'clock of a sunny afternoon in October. They came from different directions to form the swarm which contained less than a hundred mosquitoes. They circled about above a projecting mass of foliage. Mating of a number of individuals occurred, and by 5.30 o'clock the swarm began to diminish.

In the opinion of Kulagin (1907), based upon at least six years

of observation of *Anopheles* in Russia, mating occurs in the autumn except in a few isolated cases, where it occurs after hibernation. The hibernating females deposit the eggs during the whole of the next spring and summer, and the September and October larvæ result from the isolated cases. Accordingly, he is of the opinion that there is but one generation in a season, the newly developed forms not depositing eggs until after hibernation. There has been insufficient study of this subject.

The eggs are laid singly and a number of times by each individual during a single breeding season. Dr. Duprée found that specimens of *A. punctipennis*, which were kept in the laboratory and supplied with blood, would lay at six or seven different periods, with a total number of more than 2,000 eggs. As many as nine layings were noted in one case. The eggs, from 100 to 300 at a time, are deposited separately, or sometimes in clusters of just a few. They are apt to float below the surface, although some of them are on the surface. Stirring the water will bring a good many eggs to the surface, from which they soon disappear again. They seem not to possess so perfect a means of keeping afloat as is recorded of the eggs of *Anopheles maculipennis*, which has the light clasping membrane about the whole rim of the egg. In *A. punctipennis* this clasping membrane is restricted to the sides. It is very delicate, apparently, for in several instances it was badly broken, or had perhaps been eaten away. A young crustacean was seen to devour the clasping membrane from one side of an egg.

The egg (fig. 1) is .55 mm. in length, mottled in appearance, and dark brown in color with blotches of silvery white. At the end are scattered light and dark spots, the former of which have been called "knobs" and which are arranged in a more or less regular pattern. Sometimes the eggs lose nearly all their dark color, and float. They float with the concave surface underneath. The larva breaks through the convex surface at the larger end, leaving a little fragment of the shell cut out on three sides, and bending over like a little canopy at one end of a little boat.

First Stage of the Larva (fig. 2). At first the young larva spends periods of time quietly. Suddenly it will start a strong current of water by means of the rotary brushes, which are large in proportion to the remainder of the body. These are fully developed

from the first. With these it sweeps in any small particles in the surface film. It takes but a short time to exhaust the immediate supply, and so the larva moves from place to place. Frequently it bends and brushes over its whole body as far as it can reach, removing anything like vorticellæ or diatoms. Sometimes these develop too rapidly and it is not at all uncommon to find larvæ less than three days old, thickly fringed with these sessile forms. Of course, such as attach themselves to the head and anterior part of the thorax remain there, being out of range of the jaws.

If food particles are scarce, the larva will brush over any algæ or other plants that may be at the surface. One very small larva was seen to remain down below the surface film for about half a minute in search of food. One of these very young ones was seen to eat a short filament of fine *Spirogyra*, when the larva was less than two days old. It refused a row of diatoms. It started back from an on-coming rotifer immediately in front of it. The same rotifer ran into and over the long anterior bristles from the thorax and the young larva gave no response. But when it happened again from the front, the larva darted away. The most conspicuous movement of an *Anopheles* larva of any age is its turning of the head through an angle of 180 degrees, when feeding. The young larva does this with energy whenever feeding on surface particles. It turns the head always in the same direction—counter-clock-wise, as was determined by the periodical disappearance of a *Vorticella* which was attached to the side of the head. This always moved downward and out of sight before appearing at the other side.

The young larva measures from .7 mm. to .8 mm. in length, not including the hairs at either end of the body. The second and third segments of the thorax have not yet united and the head is very prominent. The dorsal surface is dark brown in color, except where there are conspicuous yellow spots, which are caused by the cenocytes within. On the segments of the thorax and on five of the segments of the abdomen these yellow spots are very noticeable, especially on the third segment of the abdomen. The head is colored an even gray, with a dark spot in the center, and one small spot on each side. The single eyes and "collar" are reddish in color and remain so during the first day. The branched

hairs from the sides of the head, outside the antennæ, are relatively longer than in any succeeding stage. The six bristles across the dorsal surface of the head (a) are unbranched, as are the two hairs which lie between the brushes and the central terminal hairs, which remain unbranched throughout the larval life.

The most conspicuous structures of the head of the young larva are the long simple hairs on the top, and the long lateral hairs at the side of the head, which with hairs of the antennæ form a barricade. Four simple hairs and the absence of a rudder-like tuft on the ninth segment (a) of the abdomen, are characteristic of the first stage.

When about two days old the larva will have changed considerably in appearance. It will measure by this time about 1.5 mm. in length. The thorax will have become distinctly formed and the long hairs will appear somewhat shorter. The head will have quite a different shape from that of the larva of one day. It will have become very dark, especially the "collar" which will be almost black. The head is much narrower and deeper. The integument has a snug, tight-fitting look (fig. 3). This figure shows a larva in the act of molting for the first time. In this case it died in the process, the integument of the thorax having failed to split apart.

For some time previous to each of the molting processes in the larval life, the head shows this peculiar narrowing, with the increased width and deepening color of the "collar." The larva measures just the same after the molting process as before it. In this case it was 1.5 mm.

Second Stage of the Larva. The changes at the time of the first molting are conspicuous. Although the thorax is distinct and large, the head is even larger (fig. 4). The four dorsal hairs of the posterior end have become eight (a), and the ventral tuft (b) has appeared, consisting of two rows of long branched hairs with a fan-like arrangement. On the head the simple hair just inside of each rotary brush (d) has become much branched, and is used for combing out the brush. The six simple hairs lying back of the brushes, on the top of the head, have become very much branched. The eyes are still little developed.

The yellow spots on the dorsal surface have increased in number and density, being most conspicuous on the third, fifth, and eighth segments of the abdomen, and on the thorax.

Within the thorax a clear specimen shows a number of parts: the anterior lobes of the heart with a large valve, the contractions of which synchronize with the throbbing between the tracheæ of the abdomen; the beginning of the arch of the tracheæ, surrounding the food tube, and from which branches are later given to the organs of the thorax; the three pairs of imaginal buds.

Within a few hours after the first molt, one larva was eating vigorously of fine filaments of algæ, and preferably of surface particles. It swallowed the filaments from the end, just as does the full-grown larva.

By the time the larva is six days old, it begins to show signs of the approaching second molt, which occurs from the seventh to ninth day. As before, the head becomes narrow and the "collar" dark and broad. One measured 2.2. mm. at this time, making a growth of .7 mm. in about two days.

Third Stage of the Larva (fig. 5). The most important changes which are evident after the second molt are: the rapid increase in the size of the thorax accompanied by the enlarged internal organs; the appearance of the ommatidia of the adult eye, around the larval eye; the disappearance of two pairs of the long hairs and the general shortening of all the thoracic hairs; the darkening of the integument of the head, which shows an unexpected pattern in the maculation. Eight specimens examined at this age showed almost exactly the same arrangement of pigment on the head. It may not be constant, but it is certainly more so than that of any other stage.

Respiratory Siphons (figs. 17, 18, 19). At this time it is possible to see, along with the rapid growth of the wing buds, the formation of the pupal respiratory siphons in the prothorax. From the time of the first molt, a pair of straight tubes in each side of the thorax has been evident. Now they have become more conspicuous. They seem to change their position, sometimes being close up to the anterior wall of the thorax, and sometimes they lie with the end quite away from the wall. Developing near by, at an angle with the first tube, and penetrating also through the wall, is another structure, tube-like at first, but after a time changed to form a part of the now plainly visible respiratory siphon. The siphons, also, are frequently drawn away from the integument, at other times being pushed up close to it.

Fourth Stage of the Larva. By the twelfth or thirteenth day the larva has increased in length to 4–5 mm., and it then shows the signs of an approaching molt, the darkening of the head and collar and the widening of the latter. Molting is getting to be a critical process and a great many lose their lives in the act. They are conspicuously large and cannot protect themselves meanwhile. Sometimes the integument of the head does not separate off easily. One was seen in which the head had not molted for more than twelve hours after the rest of the integument had been shed. For a day or more before the third molt, the changes about to occur are evident. They consist of the appearance of the palmate, or stellar hairs, which are of use in clinging to the surface film (fig. 7). The body needs more support in its horizontal position. The palmate hairs (ph) appear on the third, fourth, fifth, sixth, and seventh segments of the abdomen, and may be seen projecting out from the segments for more than a day before the molting. They appear quite suddenly. At the same time the reddish adult eyes have become very conspicuous and are seen to be increasing in the number of ommatidia.

After the molt, the maculation of the head appears to be different from that just after the previous molt. The pattern of the spots is the same, but the increased amount of pigment in the surrounding integument prevents the spots from showing clearly. The buds within the thorax have become very prominent by this time and in addition to the respiratory siphons and the wings, we may see the projecting buds of the legs beneath, and of the halteres. In the head, which remains especially clear for several hours after each molt, we may see now the forming buds of the antennæ (fig. 20), the main portion of the brain with nerves branching to the eyes, to the antennæ, and to the digestive tube. Numerous muscles to the mouth parts, with their relations to the muscular lining of the integument, may be seen at this time also, as long as the integument remains transparent. Now, too, the clear, dark spots between the abdominal segments first become visible (fig. 7.).

From about the fifteenth day to the twenty-second, growth is rapid, if plenty of food is available. The record of one larva in the laboratory was as follows:

- July 2—first molt (about 3 days old).
 “ 13—third molt (second not seen).
 “ 21—transformed to pupa.
 “ 23—adult female.

This makes the complete cycle occupy about twenty-four days, in midsummer in Ithaca. This specimen was taken from a spring-fed pool, was transferred to the laboratory and raised in a procelain dish in the water of the Cornell campus reservoir. Its food was *Spirogyra*, *Zygnema*, and *Mougeotia*, with *Cladophora* for browsing and to furnish surface particles. The adult which emerged was no smaller than many that have come from pupæ taken at the same pool. The only special care given was to prevent the afternoon sun from shining upon it, and to add fresh water frequently.

Some of the Records of Developing Larvæ.

- A. July 26—hatched .825 mm. long.
 27—10.30 A. M. 1. mm.
 27—3 P. M. No change, head broad.
 28—10.30 A. M. Collar wider, head dark, 1.55, mm.
 29—11.30 A. M. 1.55 mm., collar still larger, 3 days old, not molted. (Died.)
- B. July 26—hatched .825 mm. 4 hrs. old when measured.
 27—head large 1.05 mm. 18 hrs. old, 10.30 A. M.
 27—head large 1.17 mm. (About) 24 hrs. old, 2.45 P. M.
 28—head narrower, collar wide, thorax more distinct 10.30 A. M.
 “ 29— 1.5 mm., 3d day 10.30 A. M.
 “ 30— 1.5 mm., 4th day molted. (Died.) 10.30 A. M.
- C. July 25—had molted once 1.5 mm. 9 A. M.
 29—second molt, about $4\frac{1}{2}$ days between 1st and 2d molt.
 30—no palmate hairs, single eye spots, no antennal buds.
 31—large eye beginning to show, 10 days.

- Aug. 1—palmate hairs not started, respiratory siphon well developed 1 P. M.
 1—palmate hairs not visible yet, 10 P. M.
 3—palmate hairs visible, eyes distinctly double, collar wider, head narrower.
 6—molted for the 3d time, 15 days, 2 P. M.
- D. July 23—1.6 mm., had molted once, about 4 days old.
 30—4.5 mm., stellar hairs have appeared, 11–12 days.
 31—4.6 mm., 13th day (Appr.) 8 P. M. Just molted for 3d time; eyes double, palmate hairs; transparent areas of abdomen for first time.

Full-grown Larva (fig. 7). There is a period of about nine days between the third molting and the transformation to the pupa, during which there are few changes in appearance. The head usually grows darker, although in many specimens it never becomes really dark. The adult eyes show greater development of the ommatidia and the coming rounded eyes of the adult are being revealed. The "collar" becomes wider with age, and the thorax assumes a decidedly round appearance. Often the whole body is green, or an even brown, or with a white stripe, or spotted along the mid-dorsal line. These differences in color do not appear in the younger forms. Dr. Howard proved that in the case of *A. maculipennis* young larvæ fed on algæ will turn green.

The conspicuous structures of this last stage of the larva are the five pairs of palmate hairs of the abdomen, the transparent areas between the abdominal segments, and the little two-lobed projections of the prothorax, which are indications of the developing respiratory siphons of the pupa.

When not in use, the palmate hairs are folded against the body. They have been clearly described by Nuttall and Shipley (1900) for *A. maculipennis*. Like all the other forms of hairs of the larva's body, they are wonderfully fitted to their work of holding to the underside of the surface film. They are not found on the first and second segments of the abdomen. On about the last day before the change to the pupa, there suddenly appears on the first segment of the abdomen a large tuft of branched hairs, a certain indication of approaching pupation (fig. 7).

The transparent areas of the segments of the abdomen are like

windows into the interior. Here we may see the rhythmic pulsations of the long heart.

Notched Processes of the Thorax. On the prothorax are two notched projections just over the respiratory siphons. In one specimen, on the second day after the third molting, an opening was plainly visible at the base of both the first and the second hairs on each side of the thorax (fig. 19). The delicate two-lobed structure had developed between the hairs and the openings. After a time the two hairs fell off, the inner one falling several hours earlier than the outer. This left the third hair, which is branched, with the two delicate processes and the openings close to them. Each opening is rimmed with several little ridges placed parallel to the hairs. The transparent lobes would seem to protect the openings. Within, each leads into one of the two tubes before described, and which must lead into the tracheal system, although their connection with the tracheæ is not evident from the outside. The openings are situated just where the thorax is applied to the surface film, and are related to the respiratory siphons of the pupa.

The Change to the Pupa. After the tuft of branched hairs has appeared on the first segment of the abdomen, we may look for the change to the pupa before many hours. The thorax will soon show a series of transparent spots, suggesting the areas in the abdominal segments, and due, doubtless, to the segmented structure of the thorax. The throbbing heart becomes plainly visible along the mid-dorsal line. The following record of the time was kept as one specimen changed: (8.30 P. M.) The larva was perfectly quiet for a long time, with the antennæ and hairs of the head drawn up close. The body expands frequently and the head is drawn in somewhat. The hairs on the thorax lie limp, pointing downward. The sides of the metathorax become somewhat sunken, as if parts beneath had changed position, (9.40 P. M.) Tiny dots on the rims of the respiratory siphons show through the transparent integument. (These may be identified later on the edges of the siphons of the pupa.) There is a rowing motion of the hairs of the whole body, and a regular pushing with the posterior end against the sides of the watch glass. In the abdomen, fine ridges or wrinkles appear across the segments, between the palmate hairs. (10.15 P. M.) The segments of the abdomen begin

to draw up, with a strong pulling away from the posterior end. (10.20 P. M.) The integument of the anterior end splits all at once, very quickly, and the two siphons are drawn out instantly, the rest of the body being drawn out with a sudden twist. (10.22) It has shaken off the skin and lies quietly expanding once more. The actual change has taken place in a little less than two minutes. After ten minutes, with a final jerk, it is a fully developed pupa, darting here and there.

The Pupa. The color of the pupa is similar to that of the larva, showing either the stripe or the blotch of white, or else being green or brown. They all turn quite dark before emerging. The pupal period is about two days.

One specimen which had changed to the pupa at 7.30 P. M. on July 1, at 5 P. M. on July 3 had emerged as the adult. The thermometer was above 90 degrees during both days. By the beginning of the second day the pupa showed evidence of the coming change.

At the anterior end of the pupa three parallel grooves appeared, the central one of which lengthened as the hours passed. Two dark spots suddenly appeared near the anterior end. Across the thorax between the respiratory siphons came a transparent place in the integument, in the center of which the heart was seen. Above the heart is a mass of striations arranged in a V-shaped structure. Each of the striations shows a dark rounded base or origin, and when compared with the thorax of the adult is plainly a hair. They appear at the beginning of the second day, and grow more distinct.

The Emergence of the Adult. After the changes mentioned above, the whole pupa becomes very dark in color, and remains very quiet, except for frequent quiverings. The heart beats more rapidly than hitherto, as may be seen through the transparent integument. Suddenly the abdomen becomes straight and the body erect. Through the skin the stigmata within the thorax may be seen in pulsation close to the wings. Before we are aware of any break in the pupa case, the head and mouth parts are completely out. They remain bent downward for considerable time, the wings, abdomen and legs being gradually drawn out. The wings come first and are kept flat and folded over one another, the spots being clearly visible from the first, although the whole wing

is pale in color. The abdomen, greenish in color and very flexible, begins to move backward and forward with a pushing motion. Here seems to be the center of all the motion. Finally the abdomen is completely extricated and pushed backward, outside the case. Now comes the most critical part of the process. The two fore legs are drawn out together, being kept parallel with one another. Similarly the second and third legs of each side are kept parallel. The second pair separate from the third pair, and are removed from the cases at exactly the same instant. Then the first and second pairs are spread out firmly on the water, or other support if possible, and all the effort is concentrated on the removal of the third pair which are much longer than the others. Unless an accident occurs, they will be pulled out together and placed firmly out backwards. Then the insect will rest quietly during the hardening of all the parts. The antennæ of a male mosquito were kept folded tightly for several hours after emergence. During all the process the pupa case rested up against the side of the watch glass. In one instance we moved the pupa case away from the glass as the process was going on, which apparently caused failure in extricating the hind legs, and death of the mosquito. Within the cast-off pupa case may be seen, at first, a large air bubble which is of service in balancing the emerging insect. (Nuttall and Shipley, 1907.)

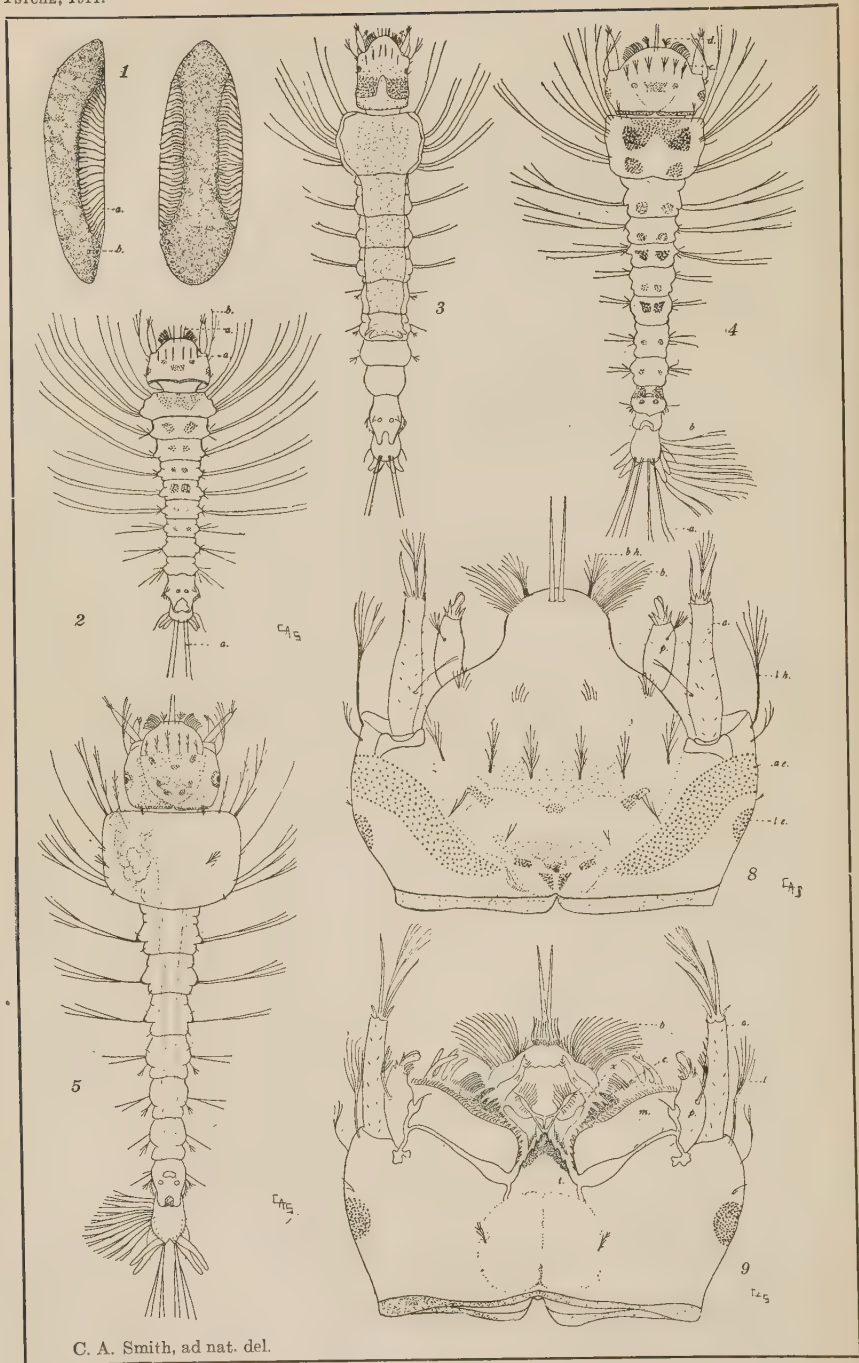
The colors of the parts of the insect as it was emerging under electric light were remarkable, the eyes being a deep iridescent green, the legs dark green, the abdomen light green with gray edges, and the yellowish spots of the wings becoming more and more distinct. Within ten minutes from the beginning of the process of emergence, our mosquito had spread its wings.

DIFFERENTIAL CHARACTERS APPEARING DURING DEVELOPMENT.

	Growth (average).	Change.	Period.	Characteristics.
Egg	.55-.57 mm.	2d-3d day (hatching)	2-3 days	Irregular spots; clasping membrane on sides only.
Larva 1st Stage	.8-1.5 mm.	4th day (molt)	3-4 days	Metathorax free at first; 6 simple hairs on head; 2 simple hairs inside brushes; rudder hairs absent; eyes sin- gle.
2d Stage	1.5-2.2 mm.	8th day (molt)	4-5 days	6 branched hairs on top of head; 2 branched hairs inside brushes; rudder hairs present; eyes single.
3d Stage	2.2-4.5 mm.	14th day (molt)	6-7 days	Head smaller than thorax; head dark with pigment; eyes double; respiratory siphons forming.
4th Stage	4.5-8.5 mm.	22d day (to pupa)	8-9 days	Faluate hairs on abdomen; transparent areas on abdomen; notched processes on thorax; dorsal tuft on abdomen. (Late in forming.)
Pupa		24th day (to adult)	2-3 days	

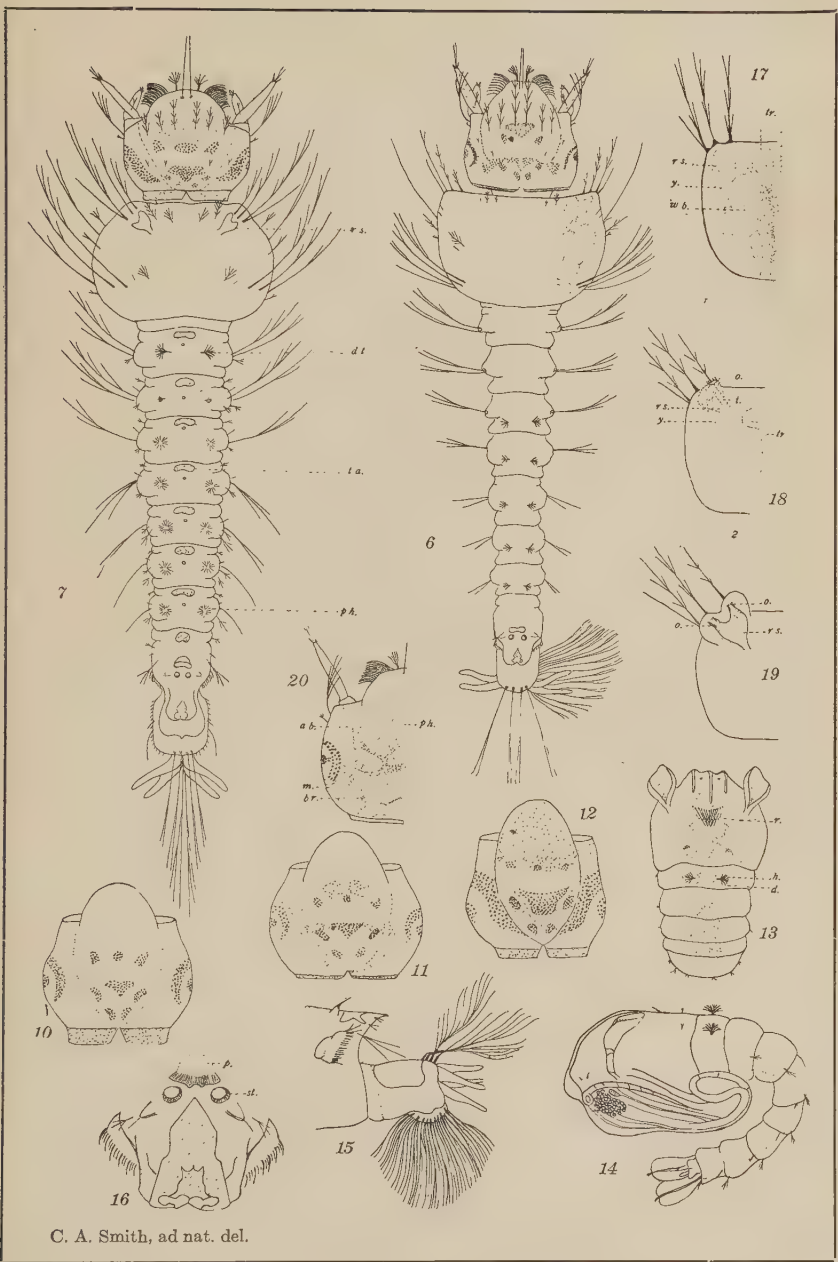
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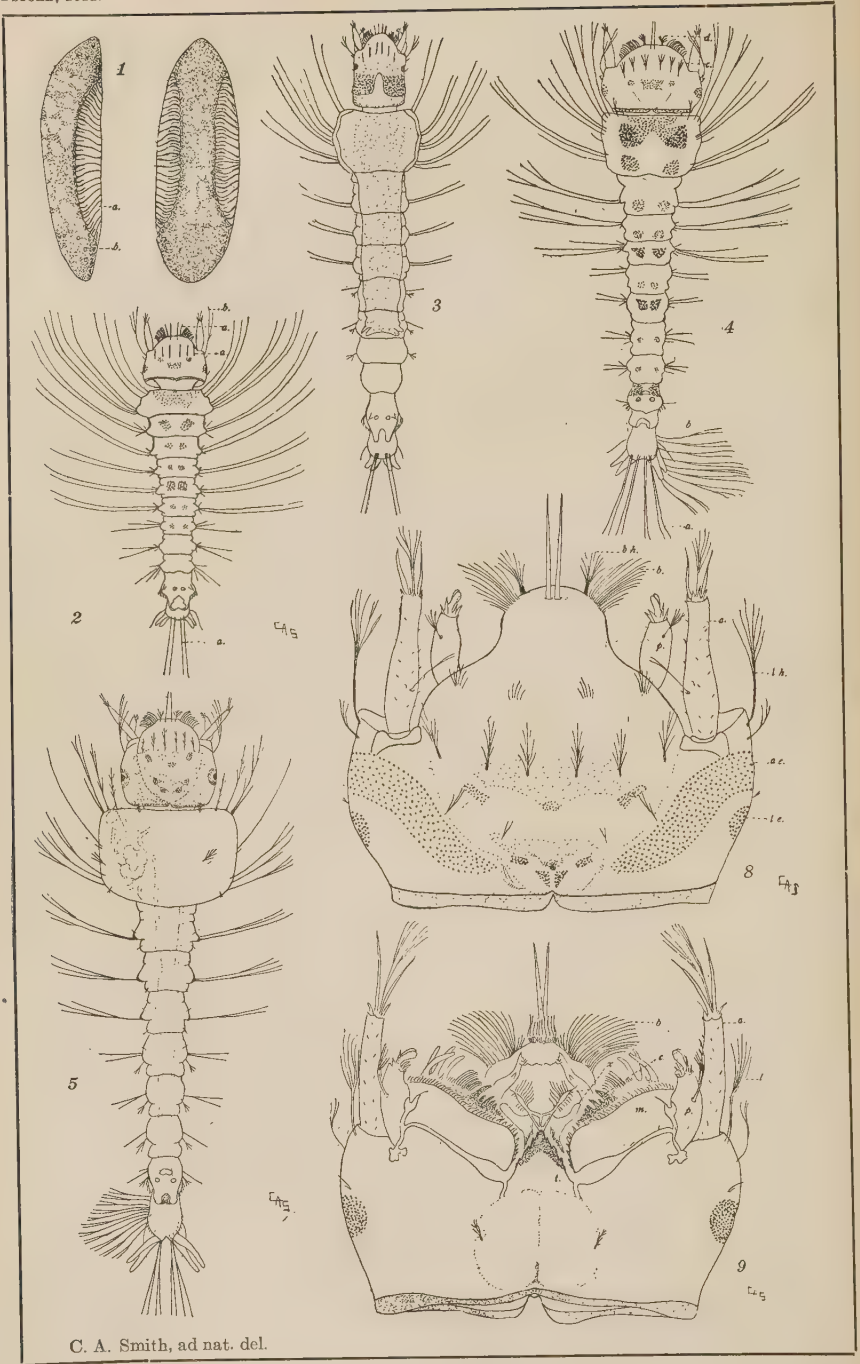
C. A. Smith, ad nat. del.

Smith—*Anopheles punctipennis*

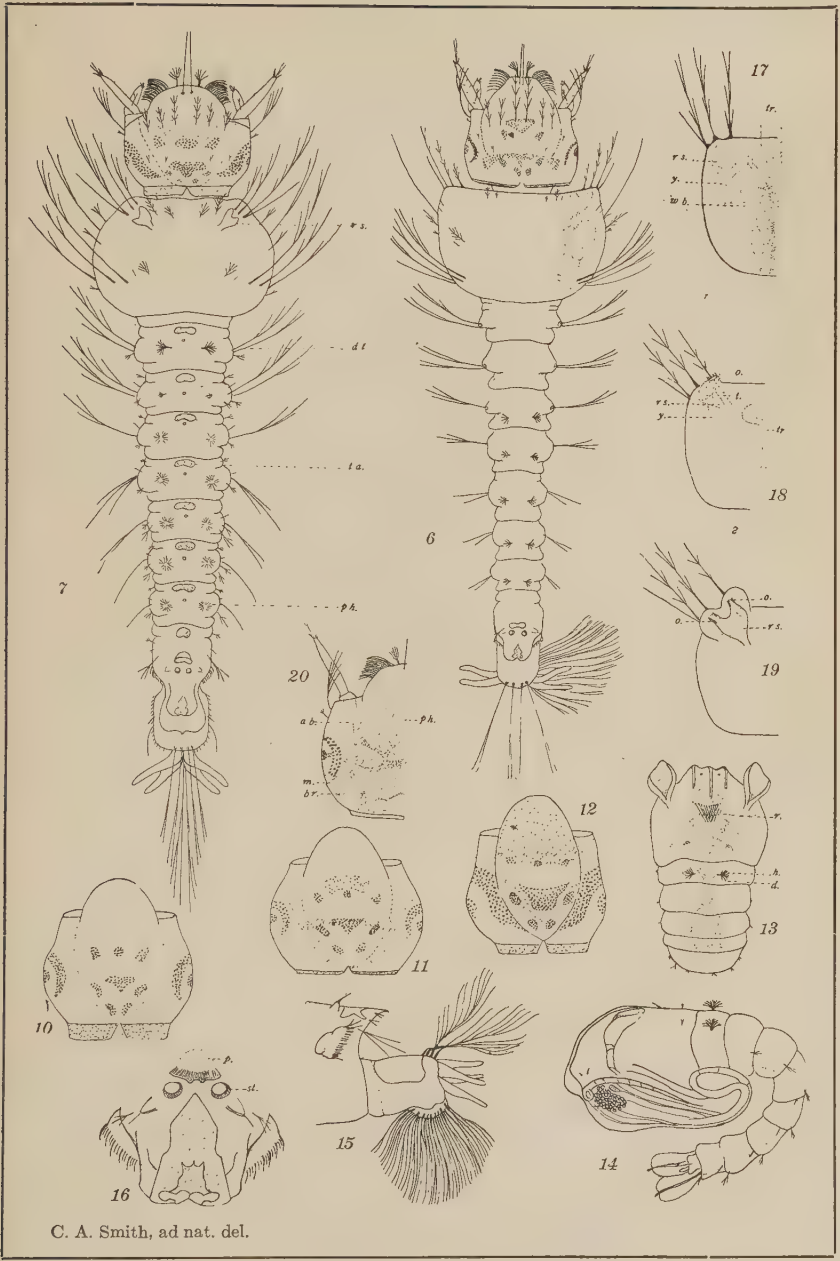


C. A. Smith, ad nat. del.

Smith—*Anopheles punctipennis*



Smith—*Anopheles punctipennis*



C. A. Smith, ad nat. del.

Smith—*Anopheles punctipennis*

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EXPLANATION OF FIGURES.

- Fig. 1. Eggs of *Anopheles punctipennis*. Actual measurement .55 mm.; (a) clasping membrane, (b) "knob."
- Fig. 2. Larva just out of the egg. Actual measurement .825 mm.; (a) hair that is branched later, (b) lateral hair.
- Fig. 3. Larva during the first molt, age 3-4 days.
- Fig. 4. Larva just after the first molt. Actual measurement 1.5 mm.; (a), (b), (c), (d) branched hairs.
- Fig. 5. Larva just after the second molt, age 8-10 days. Actual measurement 2.2 mm.
- Fig. 6. Larva just after the third molt, age 13-15 days. Actual measurement 4.5 mm.
- Fig. 7. Larva just before the change to the pupa, age 21-23 days. Actual measurement 8.5 mm.; (rs) respiratory siphon, (dt) dorsal tuft, (ta) transparent area, (ph) palmate hair.
- Fig. 8. Dorsal view of head and larva; (a) antenna, (p) maxillary palp, (b) brush, (bh) branched hair, (ae) adult eye, ('e) larval eye, (lh) lateral hair.
- Fig. 9. Ventral view of head of full-grown larva; (b) brush, (c) teeth of mandible, (m) maxilla, (p) maxillary palp, (a) antenna, (l) lateral hair, (t) mentum, (x) chitinous structures within the mouth.
- Figs. 10, 11, and 12. Maculation of the head of the larva; (10) just before the third molt; (11) just after the third molt; (12) just before the change to the pupa. (Sometimes there is more pigment; often less.)
- Fig. 13. Dorsal view of pupa on the second day; (d) dorsal tuft, (h) outline of one of the halteres, (r) dorsal hairs of adult, showing through the pupa case.
- Fig. 14. Side view of pupa.
- Fig. 15. The ninth segment of the abdomen from the side.
- Fig. 16. Stigmata of eighth segment of the abdomen of a full-grown larva; (st) stigma, (p) plate which folds over the stigmata when the larva is below surface film.
- Fig. 17. Showing buds of wings and of respiratory siphons in the thorax of the larva just after the first molt; (tr) trachea, (rs) bud of respiratory siphon, (wb) wing bud, (y) movable tube.
- Fig. 18. Respiratory siphon just after the second molt; (y) movable tube, (t) tube, (rs) respiratory siphon, (tr) trachea, (o) opening.
- Fig. 19. Respiratory siphon (rs) of larva just before the change to the pupa, (o) openings.
- Fig. 20. Some of the organs of the head as seen just after the third molt; (ab) bud of antenna, (ph) pharynx, (br) brain with nerves to eye, antenna and pharynx, (m) muscles to mouth parts.

SOME NEW AND INTERESTING SPECIES OF
SAPROMYZA.

BY CHARLES W. JOHNSON.

Boston Society of Natural History, Boston, Mass.

The recent synopsis of the Sapromyzidæ by Prof. A. L. Melander (PSYCHE, vol. XX, pp. 57-88, 1913), induced me to go over some material that had accumulated for several years. The results were something of a surprise. The series represented by the following species is what one would expect to find if he had only the two extremes, but the fact that practically all of the intermediate species really exist is doubly interesting.

Two of the species suggest the remarkable posterior tarsi of *Platypeza* (*Calotarsa*), thus presenting an interesting case of parallelism.

It is also interesting to note the wide distribution of some species and the apparently restricted distribution of others. Their similarity in size and color is probably one of the causes why these new species have been overlooked so long, and more careful collecting will undoubtedly show that these are more widely distributed than here indicated.

Sapromyza ornatipes sp. nov. Pl. 3, figs. 1, 2, 3.

Male: Face, front and antennæ yellow, the front slightly darker than the face, arista black, base yellow, pubescence short. Thorax yellow, slightly pruinose, hairs black, with three dorso-centrals, scutellum yellow with four large marginal bristles. Abdomen dark yellow. Halteres and legs light yellow, posterior tarsi whitish, metatarsi with a row of short black bristles along the outer side and two long, curved, black subapical bristles slightly broader and flattened at the ends, the two following joints as broad as they are long, black, base white, thickly covered with black hairs and with two long curved bristles on each, similar to those on the metatarsi, the remaining joints brownish at the tips, with small black bristles and hairs. Wings hyaline, clouded with brown, the latter starting near the junction of the second and third veins and extending to a little beyond the anterior cross vein and along the costa from near the end of the first to the end of the fourth vein, with a partial interruption just beyond the end of the second vein, a band also extending across the wing covering the posterior cross vein. Length 3.5 mm.

Female similar to the male except that the posterior tarsi are not differentiated, although the second and third joints are black.

Six specimens. Holotype and allotype, Mt. Everett, Mass., June 27, and paratypes, Mt. Everett and BashBish Falls, Berkshire Co., Mass., June 28, 1912 (C. W. Johnson and J. A. Cushman), in the collection of the Boston Society of Natural History.

Sapromyza melanderi sp. nov. Pl. 3, figs. 4, 5, 6.

Male: Front and antennæ bright yellow, the face and occiput light yellow, arista pubescent, black, base yellow. Thorax dark yellow, with three dorso-centrals, scutellum yellow with four marginal bristles. Abdomen dark yellow. Halteres and legs light yellow, posterior tarsi whitish, tip of the metatarsus black and broadened, the following joint as broad as it is long, black with the basal third-white, the next joint only slightly broadened apically and these joints are each armed with two longer, curved black bristles as in *S. ornatipes*, but less flattened at the ends. Wings hyaline with the cloudings less distinct than in the preceding species, the costal clouded area being often obsolete beyond both the anterior cross-vein and the end of the second vein, and the band extending to the posterior cross-vein interrupted. Length, 3 mm.

The female resembles the male except that the posterior tarsi are simple, the tips of the metatarsi and the outer half of the following joints black.

Eight specimens. Holotype and allotype, Providence, Mass., June 24, Paratypes, Eastham, June 27 and, Barnstable, Mass., July 5, 1904 (C. W. Johnson); Nantucket, July 4, 1906 (J. A. Cushman) and Aug. 7 and 15 (H. T. Fernald).

Sapromyza compedita Loew. Pl. 3, figs. 7, 8, 9.

A common and widely distributed species. The second joints only of the posterior tarsi black and as broad as they are long. The clouding of the wing is confined to the apical portion above the posterior cross-vein, with only a small clouding at the anterior cross-vein.

Sapromyza houghii Coquillett. Pl. 3, figs. 10, 11.

The posterior tarsi are similar to those of *S. compedita* except that the second joints are slightly smaller. The clouding on the wing however is closer to that of *S. melanderi*.

I have collected and received this species from the following localities:—Blue Hills, June 16, Eastham, June 27, Edgartown, June 28 and Horse Neck Beach, Mass., July 30 (C. W. Johnson); Sharon, Mass., Aug. 3 (J. A. Cushman); Kingston, Aug. (John Barlow); West Thompson, Conn., July 12 (H. L. Viereck); Wash-

ington, R. I., June 19, Atco, N. J., June 12 and Suffolk, Va., June 11 (C. W. Johnson).

Sapromyza sheldoni Coquillett.

This has the clouding of the wings very similar to that of *S. ornatipes* except that both the costal and subcostal cells are clouded. The posterior tarsi are not differentiated.

Additional records for this species are Fort Kent, Me., Aug. 19 (C. W. Johnson); Orono, Me., Aug. 13 (C. P. Alexander); Wellesley, Mass., July 11 (E. P. Van Duzee).

Sapromyza disjuncta sp. nov. Pl. 3, figs. 12, 13.

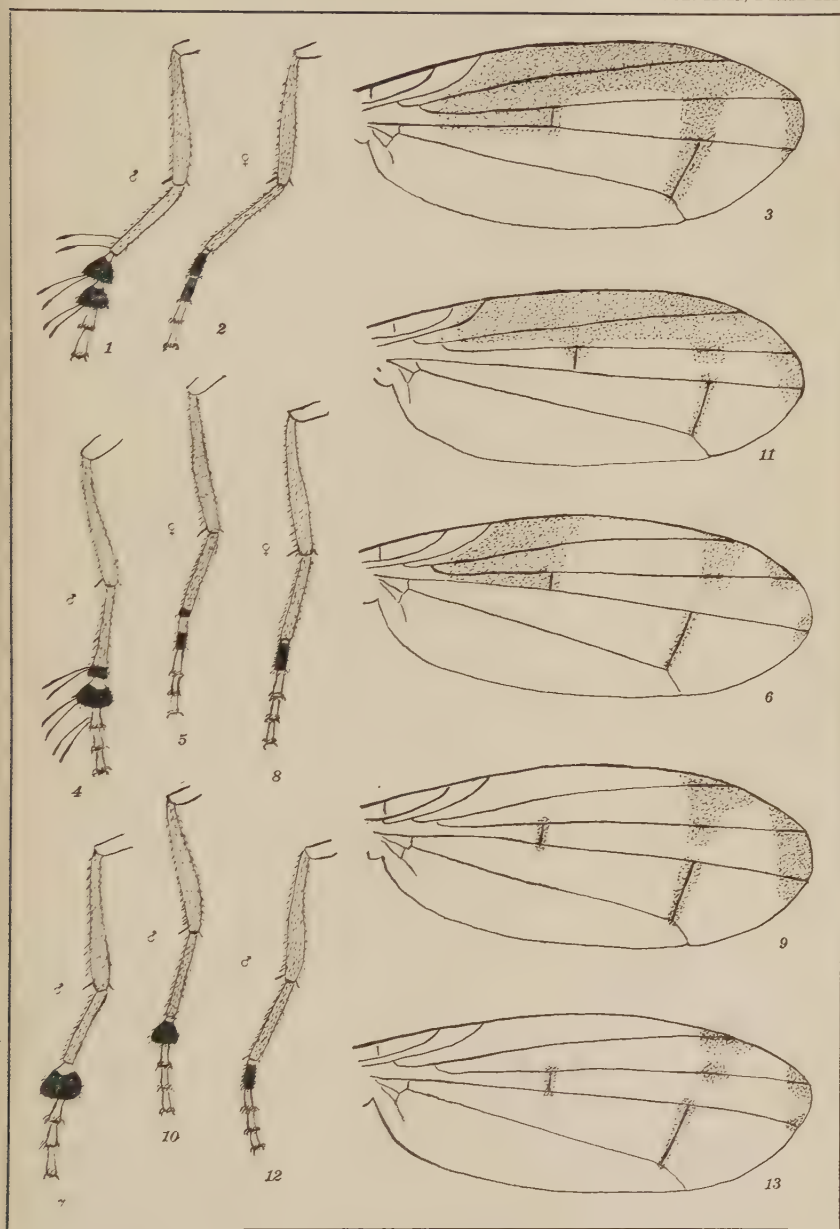
Male: Face, front and antennæ yellow, arista black. Thorax dull yellow, slightly pollinose, four dorso-centrals; scutellum yellow. Abdomen yellowish brown, lamellæ large, whitish, fringed with long, black hairs. Halteres and legs yellow, tarsi whitish, the second joints of the posterior tarsi black, scarcely enlarged, tips of the remaining joints brownish. Wings hyaline, a clouding at the anterior and posterior cross-veins, at the ends of the second, third and fourth veins, and a spot midway between the anterior cross-vein and the end of the second vein slightly fused with the clouding at the end of the second vein. Female similar to the male. Length 3.5 mm.

Twenty-two specimens. Holotype, Washington, R. I., June 19, and allotype, Buttonwoods, R. I., June 15, 1912. In the collection of the Boston Society of Natural History. Paratypes, Bretton Woods, N. H., June 25, Boston, June 6, Cambridge, June 21, Dedham, Sept. 4 and Mt. Tom, Mass., Sept. 22, Tiverton, R. I., July 31, Darien, Conn., May 27, June 11, Ithaca, N. Y., July 23, Delaware Water Gap, July 12 and Wildwood, N. J., Aug. 12, Philadelphia, June 20 and Frazer, Pa., July 24 (C. W. Johnson); Branford, Ct., (H. L. Viereck); Norway, Me. (S. J. Smith); "N. Y. and Ct." (Osten Sacken) Mus. Comp. Zool. A specimen from Jacksonville, Fla., collected by Mrs. A. T. Slosson and referred to *S. compedita* also belongs to this species.

The clouding of the wing is similar to that of *S. philadelphica* but the black second joint of the posterior tarsi distinguishes it from that species.

Sapromyza conjuncta sp. nov.

Male: Face, front and antennæ light yellow, arista blackish, base yellow, pubescence very short. Thorax dull yellow, slightly pollinose, with four dorso-centrals, scutellum noticeably lighter in color than the thorax. Abdomen reddish brown;



Johnson—Sapromyza.

lamellæ small, red, margined with brown. Halteres and legs light yellow, tarsi not differentiated, middle femora with a row of four strong bristles on the under side near the tip. Wings a whitish, not yellowish, hyaline, the clouding like that of *S. compedita* from which however, it can be readily distinguished by its simple, unicolored tarsi. Female similar to the male. Length 3 mm.

Seven specimens. Holotype, Buttonwoods, R. I., June 18, 1912. Paratypes Auburndale, Mass., Blue Hill, Mass., Aug. 2, Manomet, Mass., July 26, Amsden, Vt., July 10, Jamesburg, N. J., July 4 and Avalon, N. J., June 8 (C. W. Johnson).

EXPLANATION OF PLATE.

1. *Sapromyza ornatipes* sp. nov. Hind tarsus, male.
2. *Sapromyza ornatipes* sp. nov. Hind tarsus, female.
3. *Sapromyza ornatipes* sp. nov. Wing.
4. *Sapromyza melanderi* sp. nov. Hind tarsus, male.
5. *Sapromyza melanderi* sp. nov. Hind tarsus, female.
6. *Sapromyza melanderi* sp. nov. Wing.
7. *Sapromyza compedita* Loew. Hind tarsus, male.
8. *Sapromyza compedita* Loew. Hind tarsus, female.
9. *Sapromyza compedita* Loew. Wing.
10. *Sapromyza houghii* Coq. Hind tarsus, male.
11. *Sapromyza houghii* Coq. Wing.
12. *Sapromyza disjuncta* sp. nov. Hind tarsus, male.
13. *Sapromyza disjuncta* sp. nov. Wing.

NOMENCLATURE NOTE ON THE MALLOPHAGAN GENUS *ANCISTROCEPHALUS* PAINE.¹

The fact has recently come to the notice of the writer that the name *Ancistrocephalus*, recently employed by him for a new genus of Mallophaga, is preoccupied, having been used by Monticelli for a genus of Cestode worms in about 1890; this name, therefore, cannot be used for the Mallophagan and is herewith substituted by the name *Physconella*. The type of this genus is *Physconella kelloggi* Paine, as described in the paper referred to in the accompanying footnote.

J. H. Paine, Washington, D. C.

¹ Paine, J. H. A New Genus of Mallophaga—*Psyche*, Vol. XX, No. 5, p. 158 (1913).

FOUR NEW NORTH AMERICAN CHLOROPIDÆ
(DIPTERA).BY J. R. MALLOCH,
Urbana, Illinois.*Parectecephala dissimilis* sp. nov.

Male: Yellow, subshining. Frons parallel-sided, a little less than twice as wide as either eye; frontal triangle not occupying whole width of vertex, glossy, reaching in a narrow line to the anterior margin of frons, sides concave, a large black spot mid way between ocelli and anterior margin, ocellar region brown; surface hairs black, long and fine; post-vertical pair of bristles erect; head in profile elongate, frons projecting over one-third the length of eye, face receding much as in *Ectecephala*; face and cheeks whitish yellow, height of latter equal to over one-half the breadth of third antennal joint; antennæ of good size, situated on almost apex of projecting frons, yellow, basal joints browned, third blackened above and at apex, third joint about one and one-half times as long as broad, upper surface at apex distinctly less rounded than lower; arista white, yellow at base, covered thickly with white hairs which give it the appearance of being thickened, length of arista equal to one and one-half times that of antenna; proboscis and palpi pale yellow, the former rather large and the apical portion folded back below the basal; eyes about one and one-half times as long as high, bare. Mesonotum with faint indications of three, almost confluent, reddish yellow stripes, the lateral margin of the outer stripe on either side brown, surface hairs dark, short; pleuræ immaculate, highly glossy; scutellum flattened, the surface roughened slightly and with numerous short, black hairs, 2 apical long bristles and a number of short ones on margin. Anterior margin of abdominal segments brown; hypopygium glossy, prominent, with a projecting ventral process. Legs slender, only the last joint of tarsi, and claws black. Wings clear, veins brown; all veins distinct, only the apex of fourth slightly less distinct than the others; cross veins separated by almost as far as length of last section of fifth vein; third vein slightly upward bent at apex; third costal section two-thirds as long as second; veins 3 and 4 distinctly divergent; outer cross vein but little longer than inner, the cell enclosed by it, therefore very narrow. Halteres pale yellow.

Length: 3.5 mm.

Type: Cat. No. 15968, U. S. N. M.

Locality: Chester County, Pennsylvania, July 22, 1893. No collector's name on specimen.

This species has much the habitus of some of the species in *Diptotoxa* and also those in *Ectecephala*. From *Diptotoxa* it may be separated by the less closely approximated cross veins, and the third vein being less distinctly upturned. From *Ectecephala* the flat frons readily separates it.

Parectecephala is likely to be confused with *Eutropha* Loew, the genera being very close, if *aristalis* Coquillett belongs to the former. Becker includes this species in his genus, but I can see no reason for separating the type from *Eutropha*. The frons is unprojecting and in other respects the type agrees very well in habitus with *Eutropha thalhammeri* Strobl, which is represented in collection United States National Museum.

***Botanobia* (= *Oscinis*) *marginalis* sp. nov.**

Female: Yellow, slightly shining. Ocellar region, and back of head black; third antennal joint at insertion of arista slightly browned. Mesonotum black-gray, four equally wide reddish yellow stripes begin on anterior margin and extend to beyond middle of disk, becoming wedge shaped posteriorly; margin of disk laterally, on the posterior angle, reddish yellow; humeri and lateral margin of disk at middle pale yellow; pleuræ pale yellow, with a vertical black stripe on upper half below wing base, which joins a forwardly directed diagonal stripe extending to about midway up mesopleura, and another spot above hind coxa; scutellum black-gray on disk, the margin broadly pale yellow; postnotum black. Abdomen yellow, each segment with dark brown fore marginal band which is produced backward in center. Legs entirely yellow. Wings clear, veins brown. Halteres yellow. Hairs on body yellowish; bristles black.

Frons occupying one-third the head width; triangle ill-defined; surface hairs numerous, short, black, those near eye margin rather setulose; antennæ of normal size, third joint rather acute on upper surface at tip; arista barely longer than width of frons, pubescent; cheek at least half as high as width of third joint of antenna; eyes oval, distinctly pubescent. Mesonotum impunctate, the surface hairs short; scutellum with 4 marginal bristles, the apical pair largest, but barely longer than the length of scutellum; outline of scutellum rounded. Legs normal. Wings with third costal division slightly over one-half as long as second; veins 3-4 divergent.

Length: 1.5 mm.

Type: Cat. No. 15970, U. S. N. M.

Locality: Biscayne Bay, Florida. (Mrs. A. T. Slosson.) One specimen.

***Botanobia* (= *Oscinis*) *proxima* sp. nov.**

Female: In coloration almost similar to *marginalis*. Differing in the following respects from that species: The insect over all is more slender; the head is more elongate; the eyes are elongate oval, whereas in *marginalis* they are placed with their long axis diagonal to the line of the body; the mesonotum has the two center yellow stripes reaching to short of the middle of disk, and the outer two reaching to distinctly beyond the middle, in *marginalis* the stripes are of equal length; and the mesonotum is more distinctly shining, the pollinosity being less distinct in *proxima*.

Length: 1.25 mm.

Type: In collection of W. L. McAtee.

Locality: Wallops Island, Virginia, June 1, 1913. (W. L. McAtee.)

Botanobia (= *Oscinis*) *insularis*, sp. nov.

Female: Black, slightly shining. Head yellow; frontal triangle black, slightly shining, the surface covered with gray dusting; third joint above, and both basal joints brown; proboscis glossy brown on basal portion; occiput concolorous with triangle. Mesonotum unstriped, and like the pleuræ thickly covered with gray pollinosity; scutellum gray pollinose. Abdomen generally yellowish on basal two segments, the others brownish black, shining. Legs yellow; darkened, brownish or blackish, on all coxæ, all femora except apices, indistinctly on mid tibiæ and distinctly on middle of hind tibiæ and apices of tarsi. Wings clear, veins brown. Halteres yellow.

Slender. Frons occupying one-half the head width, orange yellow; triangle as wide as vertex, and not reaching middle of frons, margined with hairs; surface of frons with scattered black hairs; antennæ larger than usual, third joint slightly angular at upper margin of apex, distinctly pilose; arista with basal joints about two-thirds as long as apical portion and thickened, pubescence short but distinct, length of arista equal to width of frons; cheek half as high as width of third joint of antenna; palpi large, almost bare; eyes distinctly higher than long, pubescent. Mesonotum unpunctured, surface with very few weak hairs; scutellum with weak discal hairs and four marginal bristles. Legs normal. Wings with third costal division two-thirds as long as second; veins 3-4 subparallel; last section of fifth vein twice as long as penultimate section of fourth.

Length: 1 mm.

Type: In collection of W. L. McAtee.

Locality: Wallop's Island, Virginia, June 1, 1913. (W. L. McAtee.) Three specimens.

FORMICA EXSECTA IN JAPAN.

BY WILLIAM MORTON WHEELER,

Bussey Institution, Harvard University.

Among several Japanese ants recently handed to me for identification by Mr. W. M. Mann there are a few specimens representing an undescribed variety of *Formica insecta*. This species, though well known from northern and central Europe and Siberia, has not been taken hitherto east of the Altai Mountains of Mongolia.

Formica exsecta Nylander var. *fukaii* var. nov.

Worker: Length 5-6 mm.

Differing from the worker of the typical form in having the mesonotum in profile straight and sloping gradually to the mesoëpinotal constriction, instead of convex. The notch in the superior border of the petiole is distinctly narrower and shallower, the gaster is darker, being black throughout and not red at the base of the first

segment, and the posterodorsal portion of the head is much less deeply and extensively infuscated.

Described from four specimens taken by Mr. T. Fukai in the Saitama division of Japan.

OBSERVATIONS ON THE RELATION BETWEEN FLOWER COLOR AND INSECTS.

BY E. M. EAST and R. W. GLASER.

Bussey Institution, Harvard University.

In 1909 a cross was made between the small red flowered *Nicotiana forgetiana* Hort (Sand) and *Nicotiana alata* Lk. and Otto var. *grandiflora* Comes, the large white N. affinis of horticulture, for the purpose of studying certain problems of heredity. About fourteen thousand plants of the second, third and fourth hybrid generation have been grown, and it has been established beyond a reasonable doubt that each plant is completely self-sterile though it crosses easily with any of its neighbors. Several hundred carefully controlled self-pollinations have not yielded a single seed, while histological studies have shown self-fertilization to be practically impossible. On the other hand, hundreds of artificial cross pollinations have yielded capsules full of seed in almost every instance, showing with what ease cross-fertilization takes place, for artificial pollination is usually not as successful as natural pollination. The fact that every capsule formed naturally on these plants must have resulted from a cross-pollination produced by an insect, serves to excuse our adding to the already huge literature on the relations between insects and plants. The sixteen different color forms that have segregated from the original cross permit observations on the percentage of flowers cross-fertilized and the selective value, if any, of distinct color varieties.

Our knowledge of the behavior of insects relative to flowers has been greatly extended during the past few years by the work of Plateau, Forel, Lovell, Grænicer and others, but it has resulted in that obscurity which precedes aggregation and precipitation by disclosing the marvelous complexity of the relation. The adjustment between certain insect forms and certain types of flowers is

just as obvious now as when pointed out by Sprengel, but few entomologists or botanists will admit its adequate interpretation by the simple natural selection idea as believed by Hermann Müller and his followers who did not see the obstacles to this view as plainly as did Darwin.

The attitude of botanists has been affected chiefly by genetic investigation. Mendelian research and hypotheses regarding mutational evolution have at least gained a serious reconsideration of the origin, inheritance, and cause of survival of flower forms. Investigations on cross- and self-fertilization, by giving a clear and reasonable interpretation of the vigor of first generation hybrids and the converse—the apparent deterioration through inbreeding hybrids—have caused us to view mechanisms for cross-pollination at a new angle. Self-pollination gives inherently stranger races (vigor not masked by heterozygosis) and insures reproduction, but practically precludes the trial of variations not of decisive value or of various recombinations of new variations with old characters. On the other hand, cross pollination, while permitting the survival of weak types through the vigor of heterozygosis, and while rendering reproduction more dubious, does assure a trial of all new variations in all the combinations possible in a mendelian sense.

The appreciation of the intricacy of the behavior of insects toward flowers is due primarily to the knowledge of insect sense organs, to the ingenuity of the experiments of animal psychologists, and to the passing of the tendency to interpret all the actions of the lower animals as tropisms.

For these reasons the question as to whether particular flower colors have a survival value due to the preference of certain insects for them, upon which we have gathered a few data, would probably be answered somewhat as follows by the majority of biologists. Excluding any question of olfactory sense, it may be assumed that insects perceive color differences from short distances but seldom if ever exercise a choice. Night flyers, of course, perceive white much more easily than colors. These conclusions are supported by the data in the following table:

Flower color.	Total number of flowers on 10 average plants.	Total number of flowers fertilized.	Per cent. of flowers fertilized.
White.....	18,035	7,052	39.10
Yellow.....	26,686	4,836	18.12
Red.....	14,165	2,154	15.21
Purple.....	9,721	1,628	16.74

Ten average plants of each of the four colors—white, yellow, red and purple—were selected at random. The total number of flowers produced on each color type during the flowering season (July 15 to October 15) was determined by counting the places on the racemes where flowers had been. The number of capsules present was assumed to be the number of flowers fertilized, although this count is not as accurate as the first by reason of the accidental loss of capsules. Long experience with *Nicotianas*, however, leads us to believe that this error is small.

The first point to be noted is the comparatively small percentage of cross-pollination by insects. Numerous experiments on artificial cross-pollination have shown that a very small amount of pollen causes normal development of the capsules, yet the yellow, red and purple types had only about 17 per cent. of their blossoms crossed. According to the table, the percentage of white flowers fertilized was more than twice as high as any of the colored types. The reason for this is obvious. From the beginning of the flowering period, about July 15, to the end period of summer heat, about September 15, the flowers opened at about 4 p. m. and remained open until about 7.30 a.m. During the last month of flowering, the weather was so cool that the flowers also were open throughout the day. Nearly two thirds of the fertilizations occurred during the last month as could be determined by the positions of the flowers on the racemes. Furthermore the percentage of fertilizations on the white type during the last month was about the same as on the colored types. Roughly, one might say then that about 6 per cent. of the pollinations of the colored types were made by night-flyers (*Sphingidæ*, etc.), while during the same period these insects pollinated from 20 per cent. to 25 per cent. of the white type. In

other words, there was a high rate of selection of white flowers during the period when the flowers were pollinated at night, but there was no selection of colors when daylight pollinations were made by the Hymenoptera and Diptera that frequented the plants.

PHILIPPINE MOSQUITOES.

BY C. S. LUDLOW

Army Medical Museum, Washington, D. C.

Myzomyia flavirostris sp. nov.

Female: Head dark, covered with dark brown and white forked scales, and white long slender scales on the vertex, extending forward as a long tuft; antennæ brown, verticels and pubescence white, basal joint brown but not so dark as the cephalic scales; palpi dark brown the ultimate joint white, except, a very narrow brown basal band extending as a tiny brown band on the apex of the penultimate, a broad white band on the base of the penultimate and the apex of the following joint, the remainder of the organ dark brown, except a very narrow white band, at the preceding joint, very heavily scaled at the base; proboscis light scaled on the apical half, often not noticeable from the dorsal aspect, and always more marked on the ventral side, the proximal half dark brown, very heavily scaled at the base; clypeus dark brown; eyes dark brown.

Thorax: prothoracic lobes dark, with brown chætæ; mesonotum has the median third of a light brown, sometimes almost yellowish, covered with the fine tomentum so often found on Anophelines, and sparsely with golden brown hair-like scales, a well marked dark median line broadening so as to cover the "bare space," and in some specimens suggestions of other laterad dark lines, a bunch of long white slightly curved scales extending over the nape; the lateral parts are a rich dark brown. Scutellum dark brown in the median portion lighter laterad; metanotum dark; pleuræ almost black.

The abdomen is very dark, almost black, with scattered brown to golden brown hairs.

Legs: the coxæ and trochanters are dark, covered with small dark scales and chætæ; femora of the fore legs light brown, tibiæ and tarsi darker brown, unguis simple; mid-femora light brown, the rest of the leg dark brown, but the terminal tarsal joint appearing fawn colored in some lights, unguis simple; hind femora light brown, tibiæ much darker, especially toward the apex, and some specimens showing a tiny white apical spot, all the tarsal joints brown, sometimes with a suggestion of apical light spots on the third and fourth joints.

Wings, clear, covered with brown and light yellow scales. The costa as a whole is dark with five small light spots, one at the apex of the first long vein; one, extending on the first long, about on a line with the base of the second posterior cell, the third, also extending on the first is well interior to a line through the base of the fork of the fifth long vein, and the last is a tiny spot between this and the root of the wing. The wing field has many small spots the third long vein is mostly light,

with a small dark spot at its apex and one near its base; there are light spots at the fourchette of each fork cell; the stem and lower fork of the fifth long vein are mostly light with a dark spot at its apex, and one at the base of the cell; the distal half of the upper fork of the fifth long vein is white with a very small dark spot at the very apex, the sixth vein is dark; the wing-fringe is dark except for light spot at the apices of all the long veins but the second and sixth. Halteres with light stem and dark knob.

Length: about 3mm.

Habitat: Camp Wilhelm, Tayabas, P. I.

Taken: November.

I am indebted to Dr. Malcolm Watson, Klang, F. M. S., for calling my attention to this species. The wing and palpal markings greatly resemble the dark form of *funesta*, and with the hand lens the light proboscis is not sufficiently marked to call attention to it, and I had laid it aside as being probably this form of a species so common on the Philippine Islands.

Popea palawanensis sp. nov.

Female: Head black, mostly covered with dark brown flat scales, a white border around the eyes, and a narrow median portion of curved scales, white at the vertex and brown at the nape; antennæ dark brown, verticels and pubescence brown, basal joint dark with a few slender hair-like brown scales on the median aspect; palpi about one fourth the length of the proboscis, dark brown; proboscis dark brown, eyes dark brown; clypeus brown.

Thorax dark; prothoracic lobes heavily covered with white flat scales and dark brown chætæ; mesonotum dark brown with silvery white slender curved scales very closely set to form a white spot covering the cephalic third, the caudad edge is irregular, and reminds one of the "solid W" described for *Lepidotomyia magna* Theo; the remainder of the mesonotum covered with slender curved, rich, dark brown scales, except an irregular white spot just cephalad of the wing joint, and white scales forming a line around and extending on the "bare space"; Scutellum dark, partly denuded, the mid-lobe having a few white flat scales in the median line, a few white rather broad curved scales laterad of the flat ones, and then brown curved scales. The lateral lobes are denuded, except for one white and a few brown curved scales. There have apparently been five marginal chætæ on the mid and three on the lateral lobes; pleura dark brown with five or six large bunches of silvery white flat scales; metanotum dark.

Abdomen covered with dark brown scales except for rather heavy basal lateral brilliant white spots. On the venter are also heavy basal brilliant white spots sometimes extending as basal white bands, and there are on several segments, bunches of very long brown scales, so much constricted on the basal part as to appear almost petioled.

Legs brown; coxæ and trochanters testaceous with a few white scales; the fore femora white on the ventral aspect nearly to the apex, fore tibia brown only on the dorsal aspect, the ventral and lateral aspects brilliantly yellowish white; all the tarsi

brown. On the femora of the mid legs the ventral white extends on the dorsal aspect to form a white spot near the apex, the very tip being brown; the tibiae are brown except a white spot near the apex, the very tip being brown; first tarsal is basally white banded and has a white band near the apex, the tip being brown; second tarsal is basally white banded, the other tarsal joints are brown. The hind femora are silvery white except for a narrow basal brown band, a broad brown band a little beyond the mid-length of the femora, and a narrow brown band at the apex; tibiae brown; first tarsal basally white banded, and a white band near the apex; the second tarsal basally white banded, and the remainder of the tarsi are brown. Fore and mid ungues equal and uniserrate, hind simple.

Wing clear, with brown, rather long and broad-ended scales, somewhat resembling *Taniorhynchus* scales. Cells short, petioles about as long as the cells. First submarginal longer and narrower than the second posterior, bases nearly on a line; base of the third long vein and mid cross-vein meet, and the posterior cross-vein is more than twice its length interior. Halteres with white stems and heavy dark brown knobs.

Length: about 4.5 mm.

Habitat: Puerto Princessa, Palawan Island, P. I.

Taken: May.

Described from one specimen. A few specimens evidently of this mosquito have been previously received, but always in such bad condition that no description was possible.

MYZOMYIA (ANOPHELES) LUDLOWII THEOBALD.

By C. S. LUDLOW,

Army Medical Museum, Washington, D. C.

For sometime there has been quite a good deal of discussion as to the breeding habits of this mosquito, different observers claiming that it bred in fresh water, in blackish or salt water, and that it bred in either.

Without wishing to question the observations of any of those who have studied this *Anophele*, and merely because there has lately appeared the definite statement, the foundation for which I do not know, that "*ludlowii* is exclusively a saline breeder,"¹ it seems better to publish what I myself know on this point.

The specimens which I sent to Mr. Theobald, and on which the species was founded, were taken by Dr. Graves in the Province of

¹ The mosquitoes of North and Central America and the West Indies. L. O. Howard, H. G. Dyar and F. Knab. 1912.

Abra, Island of Luzon, on the Benguet Road during the construction of that road. The location is definitely inland; the camp was in a deep canyon, where Dr. Graves wrote me "the Mountains are so high we see the sun only between 9 a. m. and 3 p. m." The Benguet River runs through this canyon, and there is no sea or blackish water within many miles. These *Anophelines* were there in great numbers, the collection from which the specimens were sent to Mr. Theobald, containing about fifty specimens, *all* of them this one species.

It is also of interest to note that for a while no other species were taken, although no effort was made to that end, and during that time malarial fever was very prevalent.

This can only mean that *M. Ludlowii* may breed in fresh water, but this, by no means precludes its breeding also in salt or brackish water, for a sufficient number of other *Anophelines* are shown to breed indifferently in fresh or salt water to make it at least allowable to suppose that *ludlowii* may do the same.

NEW OR LITTLE-KNOWN NEOTROPICAL HEXATOMINI (*TIPULIDÆ*, *DIPTERA*.)

BY CHAS. P. ALEXANDER,

Ithaca, N. Y.¹

The following species were included in collections received for study from the American Museum of Natural History (Mr. Grossbeck); United States National Museum (Mr. Knab); Cornell University (Dr. Bradley); and the Museu Rocha (Señor Rocha). I express my sincere thanks to the above-named gentlemen for this and other favors received from them. The present paper deals with the *Hexatomini*, an extensive tribe of crane-flies, which reaches its maximum of specific development in the tropics. The study of these forms was conducted as research in Systematic Entomology at Cornell University under Dr. J. Chester Bradley, to whom I am indebted now, as before, for advice and many valuable suggestions.

¹ Entomological Laboratory, Cornell University.

Eriocera Macquart.

1830. *Caloptera* Guérin; Voyage de la Coquille; Zoöl.; pl. 20; f. 2.
 1838. *Eriocera* Macquart; Dipt. Exot.; vol. I, pt. 1; p. 74.
 1838. *Evanioptera* Guérin; Voyage d' la Coquille; Zoöl.; vol. 2, pt. 2; p. 287.
 1848. *Pterocosmus* Walker; List Dipt. Brit. Mus.; vol. I, p. 78.
 1850. *Allarithmia* Loew.; Bernstein und Bernsteinfauna, p. 38.
 1857. *Oligomera* Doleschall; Naturk. Tijds. v. Nederl. Ind.; vol. 14, p. 11.
 1859. *Arrhenica* Osten Sacken; Proc. Acad. Nat. Sci. Phil.; p. 242.
 1859. *Physecrania* Bigot; Ann. Soc. Ent. Fr.; p. 123; pl. 3, fig. 1.
 1912. *Androclosma* Enderlein; Zoöl. Jahrb; vol. 32, pt. 1, p. 34, fig. U, V.

Eriocera is one of the dominant genera of the crane-fly fauna in Neotropical countries. The key given below is based on a study of specimens of many of the species and a careful consideration of the original descriptions. It should, however, be supplemented by the original description wherever this is possible.

A Key to the Neotropical Species of *Eriocera*.

1. Wings dark colored with hyaline or yellowish cross-bands, or wings light colored with dark cross-bands. 2
 Wings, whether dark colored or not, uniform, or nearly so, in color, not cross-banded. 13
2. Wings light-colored with three dark cross-bands, [small species; length, ♀, 8 mm.]. (Porto Rico.) *trifasciata* Röder.
 Wings dark colored with hyaline or yellowish cross-bands. 3
3. Head dark colored, not red or yellow. 4
 Head yellowish or reddish. 5
4. Base of the wings pale; femora with the basal third and a ring at the second third yellow; first four abdominal segments bright yellow; head with a yellowish-grey bloom. (Colombia.) *braconides* End.¹
 Base of the wings dark; legs, abdomen (with the exception of the apical segments of the ♀) and head entirely black. (Guatemala.) *magnifica*, sp. n.
5. Tip of the wing dark colored. 6
 Tip of the wing pale giving the wing the appearance of having an apical yellow cross-band. (North Brazil.) *perpulchra*, sp. n.
6. Wings pale brown with a moderately narrow, hyaline band, whose distal edge is limited by the cord; a small brownish stigmal spot [antennæ bright brownish-yellow; thoracic dorsum brownish-yellow with three greyish brown stripes; femora with middle third and apical quarter brown on a ochraceous-yellow ground]. (Colombia.) *virgulativentris* End.²
 Wings darker brown with the cross-band usually wider; stigma not distinct . . . 7

¹ Roder, V. von; Stett. Entomol. Zeitung; vol. 46, p. 338; 1885.

² Enderlein, G.; Zoöl. Jahrbuch; vol. 32, pt. 1; p. 47, (f. B¹); 1912.

³ Enderlein, G.; l. c.; p. 47, 48; (f. c¹); 1912.

7. Legs with the tibiae, at least the posterior ones, with a broad white ring. 8
 Legs without white bands. 9
8. Thorax uniformly black; [head and base of antennae uniformly fiery reddish-yellow; wing band yellow; anal cells a little less brown than rest of the brown band]. (Brazil.) *tanioptera* Wied.⁴
 Thorax not uniformly black, dorsum very faintly striped, pleurae sooty-brown; [abdomen black; a scoriaceous, bluish-black band at the base of each segment]. (Brazil.) *caminaria* Wied.⁵
9. Femora banded with yellow rings on a darker ground; [large, ♀, length, 18 mm.; head yellowish-orange; first antennal segment brown; abdomen with segments 2, 3, 4 and the terminal ones yellowish-orange, the others black]. (Brazil.) *fasciata* Guer.⁶
 Femora not banded with yellow rings; legs yellow, brown or black usually darkening toward the tips of the segments. 10
10. Antennae entirely orange; [larger; ♀, length 15 mm.; wing-bands pale yellow]. (Brazil.) *ruficornis* Macq.⁷
 Antennae with only the scape orange, flagellum brown; [smaller; ♀ less than 12 mm.]. 11
11. Thoracic dorsum blackish-grey trivittate with black; [wing band and anal cells yellowish]. (Brazil.) *melanacra* Wied.⁸
 Thoracic dorsum neither grey, nor trivittate with black. 12
12. Abdomen black, at base of each segment a shining, scoriaceous, bluish-black band. [This species is also included in couplet 8; Wiedemann does not mention white tibial bands, but specimens which Schiner determined as being *caminaria* had white on the tibiae]. (Brazil.) *caminaria* Wied.⁵
 Abdominal segments 2, 3, and sometimes 4, with at least the caudal margins whitish; bases of the segments usually reddish. (Northern S. America.) *longistyla* Alex. (= *erythrocephala* Fabr.) preocc.⁹
13. Abdomen mostly yellowish or yellowish-brown, usually with a black band before the tip. 14
 Abdomen mostly black or blackish. 26
14. Frontal tubercle black or blackish. 15
 Frontal tubercle yellowish or reddish. 18
15. Thorax red between the pronotum and the suture, with a dark median line; [abdominal segments 6 and 7 black; wings pale brownish; ♂, length, 15 mm.]. (Mexico.) *mesoxantha* O. S.¹⁰
 Thorax yellow or reddish-yellow, without a dark median line. 16

⁴ Wiedemann, J.; Aussereur. zweifl. Insekt; vol. I, p. 28; (*Limnobia*); 1828.⁵ Wiedemann, J.; l. c.; vol. I, p. 31; (*Limnobia*); 1828.⁶ Guérin, F. C.; Voyage de la Coquille.; Zool.; vol. 2, pt. 2; p. 287; pl. 20, f. 2; (*Eva nioptera*); 1830.⁷ Macquart, J.; Dipt. Exot.; vol. 1, pt. 2; p. 176, 177; (*Cylindrotoma*); 1838.⁸ Wiedemann, J.; Aussereur. zweifl. Insekt; vol. I, p. 548; (*Limnobia*); 1828.⁹ Fabricius, J.; Syst. Antliar.; p. 31; (*Tipula*); 1805.¹⁰ Osten Sacken, C. R. R.; Biologia Centr. Americana; Dipt.; vol. I; p. 10; 1886.

16. Antennæ with flagellum light yellow; thorax uniformly yellow; [abdomen with segments 3-7 with brown spots; wings brownish, lighter-colored in the interior of the cells]. (Mexico.) *flavida* Will.¹¹
 Antennæ brown or black; thorax yellow with black lateral spots or stripes. 17
17. Antennæ black; a large black spot on mesonotum above each wing; abdomen black excepting segments 1-4 and 9. (Mexico.) *brunneipes* Will.¹²
 Antennæ brown; a short black stripe on each side of the mesonotum; abdominal segments 1-4 with a narrow posterior black band; remaining segments black excepting their yellowish bases. (Mexico.)
 *willistoni* Alex. (= *fasciata* Will.) preocc.¹³
18. Cell 1st M_2 far out toward the wing-margin, so that Cu_1 beyond this cell is shorter than $Cu_1 + M_3$; that portion of R_1 between cross-vein r and Sc_2 very thin, indistinct; [antennæ of the ♂ very long, filiform, twice as long as the body]. (Eastern Brazil.) *macrocera*, sp. n.
 Cell 1st M_2 nearer to the wing root, so that Cu_1 beyond this cell is as long or longer than $Cu_1 + M_3$; R_1 between r and Sc_2 equal to the remainder of R_1 in thickness; [antennæ of the known ♂'s short]. 19, 23
19. Males with the frontal tubercle produced into slender horn-like points which are directed laterad; [abdomen with a subterminal black band]. (Bolivia.)
 *cornigera*, sp. n.
 Males (as known) with the frontal tubercle normal. 20
20. No conspicuous black subapical band on the abdomen; stigmal spot conspicuous; [length about 19 mm.; wing 17 mm.]. (British Guiana—Eastern Brazil.)
 *kaieturensis*, sp. n.
 A conspicuous sub-apical dark brown or black band on the abdomen. 21
21. Larger species; [length, 20 mm.; wing, 18 mm.; [Sc_2 longer than Sc_1]. (Ecuador.)
 *ohausiana* End.¹⁴
 Smaller species [length, 15 mm. or less]. 22
22. Antennæ brown; body coloration dull brownish-yellow. (Peru.)
 *peruviana*, sp. n.
 Antennæ yellow; body coloration yellow and black. (Mexico—Costa Rica.)
 *zonata* O. S.¹⁵
23. Females (as known) without a subapical black band on the abdomen; [length 25-28 mm.; wing, 20-21 mm.]. (British Guiana—Eastern Brazil.)
 *kaieturensis*, sp. n.
 Females (as known) with a subapical black or blackish band on the abdomen. 24
24. Mesonotum uniformly reddish-yellow; [antennæ brown; wings tinged with brownish]. (Honduras.) *obsoleta* Will.¹⁶
 Mesonotum longitudinally striped. 25
25. Scape of the antennæ yellow; legs yellow, segments tipped with black; Sc_2 longer and more conspicuous than Sc_1 . (Mexico—Costa Rica.) *zonata* O. S.¹⁵

¹¹ Williston, S.; Biologia Centr. Americana; (suppl.; Dipt.; vol. I); p. 227; 1900.

¹² Williston, S.; l. c., p. 227; pl. 4, fig. 5; 1900.

¹³ Williston, S.; l. c., p. 226; pl. 4, fig. 10; 1900.

¹⁴ Enderlein, G.; Zoöl. Jahrbuch.; vol. 32, pt. 1; p. 45, 46; fig. A¹; 1912.

¹⁵ Osten Sacken, C. R. R.; Biologia Cent. Amer.; Dipt., vol. I, p. 10; 1886.

¹⁶ Williston, S.; Biologia Cent. Amer.; Dipt.; vol. I (suppl.); p. 227; 1900.

- Scape of the antennæ brownish-black; legs blackish-brown except base of fore femur; Sc_2 shorter than Sc_1 . (Mexico.) *townsendi*, sp. n.
26. Color metallic blue with head orange-red. (Panama.) *lessepsi* O. S.¹⁷
Color not metallic blue. 27
27. Thoracic præscutum red. 28
Thoracic præscutum black. 29
28. Frontal tubercle red; scutellum black. (Mexico.) *hæmorrhœa* O. S.¹⁸
Frontal tubercle black; scutellum red. (Guatemala.) *erythræa* O. S.¹⁹
29. Frontal tubercle orange. 30
Frontal tubercle black. 31
30. Abdominal segments 3-5 with bases red dish. (Mexico.) *gracilis* O. S.²⁰
Abdominal segments altogether black. (Colombia.) *macquarti* Fnd.²¹
31. Wings luteous, blackish toward the tips. (South America.) *chrysoptera* Walk.²²
Wings mostly blackish. 32
32. Wings brown, darker along costa; cells uniform; wings not reddish-yellow at basis. (Mexico.) *pretiosa* O. S.²³
Wings brown, either reddish-yellow at base or else with hyaline in some of the cells. 33
33. Wings a little reddish-yellow at base. (Brazil.) *nigra* Wied.²⁴
Wings blackish, some of the cells with nearly hyaline streaks. (South America.) *tenebrosa* Walk.²⁵

The following species are not included in the above key:

Penthoptera fuliginosa Schiner;²⁶ (Colombia) shining pitch-black; femora with a broad yellowish-red ring immediately beyond the base; head, antennæ and palpi black; wings tinged with brown, more saturated on costal margin. Osten Sacken, (Studies on Tipulidæ, pt. 2, p. 224), suggests that this is an *Eriocera*.

Limnobia flaviceps Wied.;²⁷ (Brazil) thorax and abdomen black, forehead fiery yellow; antennæ black. Venation (Pl. 6 b; fig. 10) like *Eriocera* but cell R_2 very short.

Eriocera magnifica sp. nov.

Dark brownish-black including the head; wings dark with a broad pale yellow postmedian band.

¹⁷ Osten Sacken, C. R.; *Biologia Cent. Amer.*; Dipt.; vol. I, p. 13; 1886.

¹⁸ Osten Sacken, C. R.; *ibid.*; p. 11.

¹⁹ Osten Sacken, C. R.; l. c.

²⁰ Osten Sacken, C. R.; l. c.; p. 12.

²¹ Enderlein, G.; *Zoöl. Jahrb.*; vol. 32, pt. I; p. 45; 1912.

²² Walker, F.; *Insecta Saundersiana*; vol. I; p. 438; (*Limnobia*); 1856.

²³ Osten Sacken, C. R. R.; *Biol. Cent.-Amer.*; Dipt.; vol. I, p. 12; 1886.

²⁴ Wiedemann, J.; *Aussereur. zweifl. Insekt.*; vol. I, p. 27; (*Limnobia*); 1828.

²⁵ Walker, F.; *Insecta Saundersiana*; vol. I, p. 439, 440; (*Limnobia*); 1856.

²⁶ Schiner; *Reise Novara*; p. 42. (*Penthoptera*); 1868.

²⁷ Wiedemann, *Aussereur. zweifl. Insekt.*; vol. I, p. 550; (*Limnobia*); 1828.

- ♂, Length, 14 mm.; wing, 12.4 mm.; antennæ about 3.8 mm.
 Fore leg, fem. 7.6 mm.; tibia, 9.7 mm.; tarsus 1, 4.9; 2-5, 4.1 mm.
 Middle leg, fem. 9 mm.; tibia, 9.6 mm.
 Hind leg, fem. 9.8 mm.; tibia, 11.8 mm.
- ♀, Length, 21 mm.; wing, 16.3 mm.; antennæ about 5 mm.
 Fore leg, fem. 9.9 mm.; tibia, 10.6 mm.; tarsus, 8.4 mm.
 Middle leg, fem. 11.4 mm.; tibia, 10.9 mm.
 Hind leg, fem. 12.8 mm.; tibia, 13 mm.

♂, Rostrum and palpi dark brown; antennæ, two basal segments brown; flagellum very dark brownish-black. Front, vertex and occiput deep brown. Frontal tubercle moderately broad, deeply notched.

Thoracic dorsum dark brownish-black without distinct stripes; pleuræ more brownish. Legs and halteres dark brownish-black.

Wings (fig. 7) brown with a broad light yellow band slightly beyond the middle, its outer margin just distad of the cord.

Abdominal tergum, basal half shiny, apical half dull black. ♀, similar to ♂ but larger and the genital segment reddish. Paratype paler and evidently newly-emerged; same place and date as the allotype.

Holotype, ♂. Trece Añas, Cacao, Alta Vera Paz, Guatemala. April 5. (Schwarz and Barber.) Allotype, ♀ same locality and collector as the ♂, April 9. Paratype, ♀ with the allotype. Types in the U. S. Nat. Mus. Coll. Paratype in the author's collection.

In its blackish head, *magnifica* agrees most closely with *braconides* Enderlein (Zööl. Jahrb., vol. 32, pt. I; p. 47; fig. B¹; 1912) of Colombia; the remaining species with banded wings have the head conspicuously orange or yellow. *Braconides* differs very notably in its pale wing-basis, light bloom on the head, different leg-pattern, etc.

Eriocera perpulchra sp. nov.

Head reddish; frontal tubercle notched; wings yellow with two brown bands.

- ♂, Length, 20.8 mm.; wing, 16.6 mm.; abdomen about 16 mm.;
 Antennæ 3.2 mm.

Middle leg, femora, 10.4 mm.; tibia 11 mm.; tarsus 8.3 mm.

Hind leg, femora, 11.8 mm.; tibia 13.6 mm.; tarsus about 8 mm.

♂, Rostrum and palpi dark brown. Antennæ, segments 1-2, orange-yellow; segment 3, yellow basally, passing into dark brown at the tip; remaining segments dark brownish-black. Front, vertex and occiput bright orange, rather obscured posteriorly. Frontal tubercle very broad, truncated in front and broadly notched.

Pronotum very dark brown. Mesonotum, præscutum, medially broadly dull chocolate-brown with three narrow darker lines, one median, the other two on the sides of the broad median band, these dark vittæ becoming indistinct behind; sides of the sclerite anterior to the pseudosuture brighter, orange; sides of the præscutum behind, dark colored; scutum, scutellum and postnotum dark brownish-black. Pleuræ dark brown, rather lighter colored on the ventral sclerites. Halteres, stem

brown, basally, darkening to brownish-black on the knob. Legs: coxæ and trochanters dark brown; femora dull brownish-yellow, tip broadly dark brown, an indistinct broad darker median band; tibiæ and tarsi brown, the former lighter colored basally.

Wings: pale light yellow; a broad brown basal band filling in the space from slightly beyond cross-vein *b* to beyond the origin of *R*₅; a second brown band filling in the space from the cord to the tip of *R*₁, down to the end of *Cu*₁. Venation (see fig. 8): *Sc* rather short, ending opposite cross-vein *r-m* before the middle of *R*₂₊₃; cross-vein *r* about equal to that portion of *R*₂ proximad. of it; *R*₅ long.

Abdominal tergites reddish-brown, segments 6-7 rather darker, brown; segments 8-9, reddish. Sternites reddish-brown.

Holotype, Savannah, North Brazil. August 22, 1911. (Crampton.) Type in American Museum of Natural History.

- *Eriocera longistyla* Alex.

1805. *Tipula erythrocephala* Fabricius; Syst. Antliar.; p. 31 (*non* *T. erythrocephala* DeGeer. 1776).

1821. *Limnobia erythrocephala* Wiedemann; Dipt. Exot.; vol. 1, p. 17.

1828. *Limnobia erythrocephala* Wiedemann; Aussereur. zweifl. Ins.; vol. I, p. 30.

1838. *Cylindrotoma erythrocephala* Macquart; Dipt. Exot.; vol. I, pt. I., p. 67.

1866. *Eriocera erythrocephala* Schiner; Verh. Zööl. bot. Ges. Wien.; vol. 16, p. 929.

1868. *Eriocera erythrocephala* Schiner; Novara Reise; Dipt.; p. 41.

1869. *Eriocera erythrocephala* Osten Sacken; Monographs Dipt. N. Am.; vol. 4; p. 248.

As I have shown elsewhere, the *Tipula erythrocephala* of Fabricius is homonymous with DeGeer's species and I have renamed it as above.

I have before me five specimens of this handsome little form, as follows:

(1) ♂, Waratuk, Upper Potaro R.; July 15, 1911. (Crampton.)

(2) ♂, Upper Potaro R.; July 17, 1911. (Crampton.)

(3) ♂ ♀, Tukeit, Upper Potaro R.; July 24, 1911. (Lutz.) (in cop.)

(5) ♀, Tukeit, Upper Potaro R.; July 24, 1911. (Lutz.)

I am including a few additional details in regard to measurements and coloration:

♂, Length, 9.1-10.3 mm.; wing, 9.9-10.4 mm.

♀, Length, 10.8-11 mm.; wing, 10.3-10.9 mm.

First and second antennal segments of the same bright orange color as the dorsum of the head; flagellum of antennæ and the palpi dark brown.

Mesonotal præscutum dark brown covered with a thick yellowish bloom which is less intense on the cephalic margin of the sclerite; three broad dorsal stripes, very indistinct. The thoracic dorsum, viewed with the naked eye, appears pearly-yellow; scutum and scutellum similar to the præscutum; postnotum darker brown, less pruinose. Wing shown in fig. 6.

Abdominal tergites, segment 1 very dark brown, only the extreme margin orange; segment 2 light orange-yellow, with a dark brown postmedian band; segment 3 orange, more yellowish on the anterior and posterior margins; segment 4, dark brownish-black, anterior quarter orange; segments 5-7 deep black, 8 and hypopygium orange. Sternites about as in the tergites; the lateral line dark on 2nd and

3rd segments. The last specimen listed above (♀) is similar but the abdominal tergum has the basal three-fourths of segments 1-3 almost black, the apical quarter yellowish. The ♀, in cop, has the first abdominal tergite black.

The specimens are in the American Museum of Natural History with the exception of specimen No. 2, in the author's collection.

Eriocera macrocera sp. nov.

Head reddish-yellow; antennæ of the ♂ twice as long as the body; the section of Cu_1 beyond the outer end of cell 1st M_2 is shorter than the fused portion of Cu_1 and M_3 .

♂, Wing, length, 8.3 mm.; breadth at widest point, 2.5 mm. Front, vertex and occiput bright orange-yellow; antennæ very long, brown.

Thorax and abdomen, brown. Wings with a slight brownish tinge; stigma darker brown, large but ill-defined; veins C , Sc and R rather yellowish; remaining veins brown. Venation (see fig. 4). Costa incassated between ends of Sc_1 and R_1 ; Sc_2 near the tip of Sc_1 ; the portion of R_1 between Sc_2 and cross-vein r , delicate, indistinct; Rs strongly arcuated at origin; R_{2+3} nearly twice as long as that portion of R_2 before cross-vein r ; the portion of Cu_1 beyond the outer end of cell 1st M_2 is shorter than the fused portion of Cu_1 and M_3 instead of distinctly longer as in all short-antennæd forms known to me; in other words, cell 1st M_2 (discal) is very far out toward the wing margin.

Holotype, ♂, Igarapé-assú, Pará, Brazil. January 30, 1912. (H. S. Parish.) Type in Cornell University Collection.

The only South American *Eriocera*, so far described, with elongate antennæ in the male. From the related Northern species, *E. longicornis* Walk., it differs in its reddish head and body-color. The type-specimen is not at hand and a more detailed description will be given later.

Eriocera cornigera sp. nov.

Frontal tubercle of the male produced into long, slender points; abdomen with a subterminal black band; general color yellow.

♂, Length, 12.8 mm.; wing 11.6 mm.; antennæ nearly 4 mm.

Middle leg, femora, 8.2 mm.; tibia, 8.8 mm.

Hind leg, femora, 9.4 mm.; tibia, 10.7 mm.

Rostrum and palpi dark, blackish; antennæ, first two segments brownish-yellow; third bright yellow; remaining segments dark brownish-black. Front brownish-yellow; vertex and occiput brownish-yellow, greyish near the eyes; frontal tubercle brighter, orange-yellow. Frontal tubercle extended into two elongate, pointed tubercles.

- Pronotum prolonged into rather long obtuse points at the antero-lateral angles, brown. Mesonotum, præscutum, median line tawny; a large, dark brown stripe beginning near the cephalic margin, narrowing behind and gradually converging to near the suture. To either side of this, near the middle of the sclerite, begins a broad stripe which runs to the suture; ground color of the sclerite yellow. Scutum

largely brown, tawny in the middle; scutellum and post-scutum tawny; postnotum tawny. Pleuræ yellowish-tawny; sternum light yellow. Halteres tawny, knobs rather darker. Legs brownish-yellow, scarcely darker at the apices of the segments.

Wings: cells *C* and *Sc* tinged with yellow, rest of wing greyish; stigma very indistinct, rounded. Venation (see fig. 3.). *Sc* rather long, ending just beyond the level of cross-vein *r-m*; *Sc*₂ longer and much stronger than *Sc*₁, which is reduced in size and simulates a cross-vein (as in *zonata* O. S.); *R*₂ very long, nearly straight; *R*₂₊₃ long; cross-vein *r* oblique, inserted on *R*₂ just beyond the fork.

Abdominal segments 1-5, light yellow; 6-7 deep brownish black; hypopygium broken.

Holotype ♂. Songo, Bolivia. (Received from Staudinger-Bang-Haas). Type in author's collection.

Eriocera kaieturensis sp. nov.

Large species (wing 17-21 mm.); head yellow; thoracic dorsum striped; legs with a broad subapical yellow band; wings with an indistinct yellowish band before the cord, stigma distinct.

♂, Length, about 19 mm.; wing, 17 mm.; antennæ about 4 mm.

Hind leg, femur, 11.4 mm.; tibia, 11.5 mm.; tarsus, 7.4 mm.

♀, Length, about 25 mm.; wing, 20.8 mm.

Middle leg, femur, 11 mm.; tibia, 10.9 mm.; tarsus, 8.9 mm.

Hind leg, femur, 14.3 mm.; tibia, 14.8 mm.; tarsus, 8.3 mm.

♂, Rostrum and palpi brown; antennæ short, segments 1 and 2 bright orange, remaining segments brown. Front, vertex and occiput bright orange-yellow.

Mesonotal præscutum light yellowish-brown pollinose with a broad darker brown median stripe, broadest in front, narrowed to a point near the suture, this broad band including a narrow, dark brown, median line; two broad lateral stripes of the same brown color on either side, beginning behind the pseudo-suture, continuing back across the suture onto the scutal lobes; scutum light yellowish-brown, each lobe brown medially, a continuation of the lateral præscutal stripes; scutellum light brownish-yellow. Pleuræ darker brown dorsally, beneath much paler, yellowish. Halteres, stem dull yellow, knob brown. Legs: coxæ and trochanters orange-yellow, the latter with a narrow black line; femora yellow, darkened at the tip and indistinctly and broadly darker beyond the middle producing a yellow subapical band; tibiæ dull yellow; tarsi dull yellow, each segment tipped with brown. Wings: of a pale yellow color, this color rather darker, more greyish, beyond the cord and near the base of the wing; stigma conspicuous, but not dark, brown, occupying the end of cell 1st *R*₁; veins brownish-yellow. Venation as in figure 1.

Abdominal tergum, segments rich yellowish-brown, darker apically; segments 5 and 6 darker; lateral margin of the tergites dark brownish-black, producing a dark lateral abdominal line; sternum yellow.

♀, Quite as in the ♂, but larger.

Holotype, ♂. Kaietur Falls, Potaro R.; British Guiana. August 8, 1911. (F. E. Lutz.) Allotype, ♀. Savanna, North Brazil. August 20, 1911. (Cramp-ton.) Paratype, ♀. Ceara, East Brazil. (Senor D. Rocha.) Holotype and Allotype in American Museum of Natural History. Paratype in Museu Rocha, Ceara, Brazil.

The paratype differs from the type ♂ and ♀ in having the first flagellar segment of the antennæ tipped with black, the wings more unicolorous; and femora without the broad indistinct yellow band. I believe that the specimen is merely a variant of the typical species. (Length, almost 28 mm.; wing, 21 mm.)

Eriocera peruviana sp. nov.

General color dull brown; frontal tubercle orange.

♂, Length, 11.8 mm.; wing, 11.2 mm.; antennæ about 2 mm.

Middle leg, fem., 8 mm.; tibia, 8.8 mm.

Hind leg, fem., 8.9 mm.; tibia, 10.2 mm.

Rostrum and palpi yellowish, the latter rather more brownish. Antennæ very short, brown; basal segments lighter colored. Frontal tubercle and region immediately behind it rich orange-yellow; frontal tubercle deeply furrowed. Remainder of front, vertex and occiput rich brown.

Pronotum dark brown. Mesonotum, præscutum, ground color light brownish-yellow; cephalic margin dark brown, continued backward as a stripe on either side of the narrow median line; a short brownish stripe on sides; scutum, scutellum and postnotum brownish-yellow. Pleuræ yellowish-white, a broad darker band extending from the root of the wings to the cervical sclerites. Halteres light brown. Legs: light brown, uniform. Wings: cells *C* and *Sc* brownish-grey, remainder of wings clearer grey. Venation (see fig. 5): *Sc* strong, *Sc*₂ remote from tip of *Sc*₁; *R*₂₊₃ more or less on a level with *Rs*.

Abdomen dull yellowish brown; sub-terminal three segments darker; hypopygium reddish-brown.

Holotype, ♂. Callanga, Peru. (Received from Staudinger-Bang-Haas). Type in author's collection.

Eriocera townsendi sp. nov.

Frontal tubercle orange-yellow; scape of antennæ dark brown; legs black.

♀, Length, 18 mm.; wing, 13.6 mm.

Fore leg, femora, 6.3 mm.; tibia, 7.3 mm.

Middle leg, femora, 7.8 mm.; tibia, 7.2 mm.

Hind leg, femora, 9.1 mm.; tibia, 9.5 mm.

Rostrum and palpi dark brown; scape of the antennæ dark brown, apice of segment one pale, silvery; segments 3 to 5, yellowish-orange; remaining antennal segments darkening to brown. Frontal tubercle moderately prominent and rather deeply notched, rich orange-yellow; sides of the vertex behind the eyes brown.

Mesonotal præscutum with a broad deep brown median stripe, margined with a narrow deep black line and divided by a narrow median line of the same black color; the lateral black stripe is forked near the pseudo-suture, the caudal branch ending at the pseudosutural fovea; sides of the sclerite somewhat brighter brown; scutum, lobes brown, blacker on the cephalic margin; scutellum and middle line of the scutum orange; postnotum dark brown laterally, broadly dull yellow medially. Pleuræ dark brown. Halteres deep brown, base of the stem a little paler. Legs: coxæ and trochanters deep brown except the fore trochanter which is dull yellow;

fore leg with basal quarter of femur conspicuously yellow, abruptly darkening to brownish-black; tibiæ and tarsi dark brownish black; middle and hind legs uniformly very dark brown. Wings almost uniformly brown; cells *C* and *Sc* a little darker colored. Venation: *Sc* long, *Sc*₁ much longer and more distinct than *Sc*₂; *R*₂₊₃ rather long, a little longer than *R*₂ beyond cross vein *r* and about three times as long as *R*₂ between the fork of *R*₂₊₃ and *r*.

Abdominal tergum, segments 1-4, orange-yellow; 5, extreme base orange-yellow; remainder of 5th and 6 and 7, deep velvety-black; genital segment orange. Sternum similarly colored but duller.

Holotype, ♀. Sierra Madre, Chihuahua, Mexico. Hd. R. Piedras Verdes. Alt. about 7,300 ft. (Coll. C. H. T. Townsend.) Type in U. S. Nat. Mus. Coll.

This species is closest to *zonata* O. S. but I cannot make the two descriptions agree. The basal segments of the antennæ in *townsendi* are very dark brown; there is more black on the abdomen; the legs are not yellow (except base of fore femora) but dark brown. The peculiar course of *Sc*₁ in *zonata*, apparently ending in radius rather than in costa does not obtain in the new species, where *Sc*₁ ends in costa, *Sc*₁ being about twice as long as *Sc*₂.

Eriocera erythræa Osten Sacken.

1886. *Eriocera erythræa* Osten Sacken; Biol. Cent. Amer.; Dipt. vol. I, p. 11.

One ♀ from Cacao, Alta Vera Paz. April 12, 1906. (Schwarz and Barber).

The mesonotal præscutum shows indications of darker brownish stripes of which the median is more double. Venation: *Sc* long, *Sc*₁ strong, ending about opposite the fork of *R*₂₊₃; *Sc*₂ weak, much shorter than *Sc*₁. *Rs* almost in a line with *R*₂₊₃; *R*₂ before cross-vein *r* a little less than one-half of *R*₂₊₃; cross-vein *r* a little more than one-half of *R*₂ before it; basal deflection of *Cu*₁ under the middle of cell 1st *M*₂. The specimen is in the U. S. Nat. Mus. Coll.

Eriocera gracilis Osten Sacken.

1886. *Eriocera gracilis* Osten Sacken; Biol. Cent. Amer.; Dipt. vol. I, p. 12.

One ♂, Sierra Madre, Chihuahua, Mexico. Hacienda R. Piedras Verdes. Alt. about 7,300 ft. Coll. C. H. T. Townsend. Specimen in U. S. Nat. Mus. Coll.

The mesonotal præscutal greyish on dorsum, with three black stripes of which the median one is broadest in front, narrowed to a point near the suture; the lateral stripes which lie on the sides of the dorsal triangle are connected on the anterior margin of the sclerite with the median stripe; the sides of the præscutum are more yellowish than the grey dorsal triangle; scutum and scutellum, as well as the postnotum deep, rich brown. Venation: *Sc* rather short, ending far before the

fork of R_{2+3} ; Sc_2 much shorter than Sc_1 but strong, in a line with the cord of the wing; R_{2+3} long, as long as R_2 alone; cross-vein r about as long as that portion of R_2 between it and the fork of R_{2+3} ; basal deflection of Cu_1 as near to the fork of M as to the middle of cell 1st M_2 .

Penthoptera Schiner.

1863. *Penthoptera* Schiner; Wiener Entomol. Monatschr.; vol. 7, p. 220.

1869. *Penthoptera* Osten Sacken; Monographs Dipt. N. Am.; vol. 4, p. 256.

A Key to the American Species of Penthoptera.

1. Small (wing less than 8 mm.); mesothoracic præscutum with the ground color obscured by a greyish or bluish pruinosity, dorsal stripes not distinct; metatarsi of the legs white; cell M_1 of the wings present, i. e., M_1 and M_2 separate at the wing-margin. (Eastern U. S.) *albitarsis* O. S.¹
- Large (wing more than 9 mm.); mesothoracic præscutum yellowish with four shining blackish marks; metatarsi of fore and middle legs more or less brown; cell M_1 of the wings lacking, i. e., M_1 and M_2 fused to the wing-margin. (Guatemala.) *conjuncta*, sp. n.

The new species described below is a typical member of the genus *Penthoptera* as defined by Osten Sacken (Monographs, l. c., p. 256, 257). It agrees with *albitarsis* O. S. of Eastern North America, and *chirothecata* Scop. of Central and Southern Europe, in its snowy-white tarsi, a character not yet found in *Eriocera*, so far as I can discover. It differs from these two species, and comes closest to *cimicoides* Scop. of Central and Southern Europe in the lack of cell M_1 of the wings; from the last-mentioned species, it differs in tarsal and body-coloration, etc.

Mr. F. W. Edwards², in his recent comprehensive paper on the Seychelles Tipulidæ, has questioned the generic validity of *Penthoptera*. The group is, indeed, founded on rather trivial characters, but these, as defined by Osten Sacken, are numerous and apply very well to the typical group of species. *Penthoptera fuliginosa* Schiner, the only form ever described by the founder of the genus was considered by Osten Sacken to be a species of *Eriocera*. In case *Penthoptera* is reduced in rank, Schiners *fuliginosa* will require renaming.

Penthoptera conjuncta sp. nov.

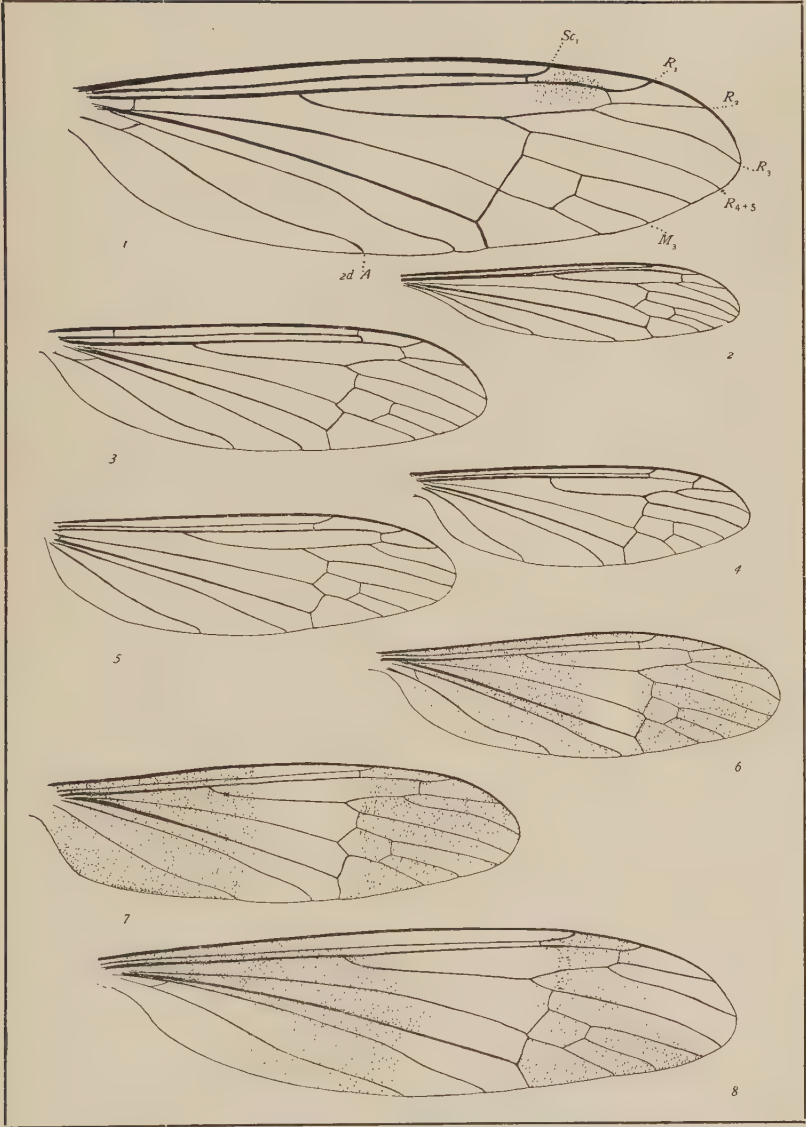
Thoracic dorsum yellowish with four dark marks; tarsi white; cell M_1 absent.

♂, Length, 9.5 mm.; wing, 9.8 mm.

♀, Length, 10.6 mm.; wing, 10 mm.

¹ Osten Sacken, Monographs, vol. 4, p. 257, 258. See Needham, 23rd Rept, N. Y. State Entomologist for 1907, plate 12, figure I, for photo of wing.

² Edwards, Trans. Linn. Soc. Lond.; 2nd series, Zoölogy; vol. 15, pt. 2; Sept. 1912. The Percy Sladen Trust Expedition to the Indian Ocean in 1905—No. 14—Diptera, Tipulidæ; p. 195-214; pl. 10-11.



Alexander—Neotropical Hexatomini

Rostrum and palpi brown; scape of antenna light yellowish-brown, the basal segment slightly darker than the second segment; flagellum broken. Front, vertex and occiput dark-colored, thickly bluish-grey pruinose. Frontal tubercle prominent, not notched.

Mesonotum yellowish-brown, shiny, a narrow deep brown line on either side of the broad dorsal median portion, beginning above the pseudosutural region, narrowing behind and ending before the transverse suture; a large rounded brown spot on the sides of the sclerite before the transverse suture; scutum, scutellum and postnotum yellowish-brown with a faint greyish bloom; a rounded darker brown spot on the lateral lobes of the latter. Pleuræ very light yellow, a large rounded brown spot on the mesopleuræ underneath the wing-root and less distinct spots on the propleuræ and cervical sclerites forming an interrupted dorso-pleural band. Halteres deep brown. Legs: coxæ and trochanters light yellow; femora yellowish-brown, extreme tip darker brown; tibiæ brown; fore metatarsus brown on basal two-fifths, remaining portions of fore tarsi pure white except the last segment which is brownish; middle leg, with the basal third of the metatarsus brown; metatarsus of the hind legs entirely white. Wings: subhyaline or slightly tinged with darker, especially toward the tip; veins dark brown. Venation, see figure 2.

Abdominal tergum with the segments dark brown; segment 1 pallid at base, darker apically; extreme margin of segments 2-6 pallid; 7-8, not pale at tip; ♂ hypopygium reddish-brown; sternites dull yellow.

Holotype, ♂. Patalue, Guatemala, Central America. 700 ft. (Dr. G. Eisen.) Allotype, ♀, with the type. Received at the National Museum, January 6, 1903. Type in U. S. Nat. Mus. Coll.; allotype in author's collection.

EXPLANATION OF PLATE IV.

The figures are all drawn to scale by means of a projection microscope.

- Fig. 1. *Eriocera kaieturensis* sp. nov.; wing.
- Fig. 2. *Penthoptera conjuncta* sp. nov.; wing.
- Fig. 3. *Eriocera cornigera* sp. nov.; wing.
- Fig. 4. *Eriocera macrocera* sp. nov.; wing.
- Fig. 5. *Eriocera peruviana* sp. nov.; wing.
- Fig. 6. *Eriocera longistyla* Alex; wing.
- Fig. 7. *Eriocera magnifica* sp. nov.; wing.
- Fig. 8. *Eriocera perpulchra* sp. nov.; wing.

THERMAL CONDUCTIVITY OF COCOONS.

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With a view toward determining the value of cocoons as a protection against extremes of temperature, thermometric tests of those of quite a number of species were made in the following manner: Normal empty cocoons were selected and the bulbs of ther-

mometers placed inside so as to occupy as nearly as possible the positions of the pupæ, that is, care was taken to have an air space surrounding each bulb. Each cocoon was fastened in place by elastic bands and then glued or sealed with wax.

The following tables show three different sets of conditions: one under normal field temperatures, one where a gradual rise takes place effected by placing the cocoon in an electric oven, and the other where a sudden drop occurs. The average length of time for the temperature of the inside of the cocoon to reach that of the surrounding atmosphere during a rise and fall was almost three quarters of an hour.

Cocoon of *Telea polyphemus*.

Field Conditions.

Outside temperature.	Temperature inside cocoon.
10°C.	15°C
8°	12°
7°	10°

Gradual Rise.

Surrounding temperature.	Time.	Temperature inside cocoon.
48°C.	0 min.	48° C.
51°	10 "	48°
55°	20 "	54°
57°	25 "	55°
60°	30 "	57°
61°	35 "	59°
62°	40 "	62°

Sudden Drop.

Surrounding temperature.	Time.	Temperature inside cocoon.
10°C.	0 min.	14° C.
2°	5 "	14°
0°	15 "	10°
0°	25 "	6°
0°	35 "	4°

Cocoon of *Bombyx mori*.

Field Conditions.

Outside temperature.	Temperature inside cocoon.
10°C.	15°C
9°	12°
7°	11°

Gradual Rise.

Surrounding temperature.	Time.	Temperature inside cocoon.
20°C.	0 min.	26°C.
44°	10 "	37°
61°	20 "	54°
66°	30 "	58°
68°	40 "	64°
75°	50 "	75°

Sudden Drop.

Surrounding temperature.	Time.	Temperature inside cocoon.
10°C.	0 min.	14°C.
0°	5 "	14°
0°	15 "	10°
0°	25 "	8°
0°	35 "	5°

Bag of *Thyridopteryx ephemeraeformis*.

Field Conditions.

Outside temperature.	Temperature inside bag.
8°C.	13°C.
7°	11°
7°	7°

Gradual Rise.

Surrounding temperature	Time.	Temperature inside bag.
26°C.	0 min.	26°C.
38°	10 "	29°
48°	20 "	42°
50°	25 "	43°
53	30 "	48°
55°	35 "	52°
56°	40 "	53°

Sudden Drop.

Surrounding temperature.	Time.	Temperature inside bag.
10°C.	0 min.	26°C.
0°	5 "	25°
0°	15 "	13°
0°	25 "	5°
0°	35 "	3°

Cocoons of *Callosamia promethea* and *Tropæa luna* gave similar results. In spite of errors due to imperfect conditions, these tables show that the temperature inside a cocoon is practically the same as that of the surrounding air and that there is a constant tendency for the inside temperature to approach that of its surroundings.

One fact, however, which is readily apparent, is that sudden changes of temperature do not occur within the cocoon. When the outside temperature was suddenly lowered as from 10°C. to 0°C., the temperatures in the cocoons fell gradually and even during a gradual rise, the cocoon temperature lagged behind that of its surroundings. This is no doubt due to the poor conducting qualities of air and silk.

As the cocoon of *Samia cecropia* is double and the pupa thereby protected by two air spaces, this was somewhat more resistant to sudden changes of temperature than the others, a longer time being required for the inside temperature to reach that of the atmosphere, when either a rise or fall occurred.

From figures showing comparative conductivity¹ one can see that air is extremely poor conductor, and also wool, the thermal conductivity of which approaches that of silk, the exact figures for silk being unobtainable. It is worth noting that the rather thin paper-like covering of the bag worm was equally as resistant to sudden changes, as the well made heavier cocoons of *Bombyx mori* and *Callosamia promethea*.

From the standpoint of temperature alone it is doubtful if the pupa needs the protection afforded by a thick cocoon, especially when we consider that pupæ of the superfamily Papilionoidea are without such coverings.

From the standpoint, of moisture however, it is exceedingly necessary for the insect to have such a covering, especially if the pupal stage is passed on the ground among leaves or in situations likely to be moist.

Cocoons of *Callosamia promethea*, the layers of which tend to fray out toward the proximal ends, which are not finished inside with coatings similar to the remainder of the interiors, when partly

¹The conductivities for heat of a number of substances is as follows: Copper, 1.041, Iron 0.167, Ice 0.0057, Marble 0.005, Glass 0.0025, Cork 0.0007, Wool 0.00012, Paper 0.000094, Air 0.000056.

submerged in water for seven hours, showed interiors perfectly dry, the water having penetrated only the outer layer. Those partly submerged in alcohol and sulphuric acid for the same time were wet clear through, the acid having softened the entire mass. Alcohol penetrated easily but did not have the disintegrating action of the acid. When totally submerged in the above liquids for one hour, the acid and alcohol readily entered the proximal end from which the moth escapes and also penetrated the sides, but water was effectually kept out, the fringe-like ends of the layers being bunched together sufficiently for that purpose, and the pressure of the air inside the cocoon undoubtedly helping also.

It is a generally accepted fact that the interiors of cocoons are coated all over with a gummy resinous substance, also that the emergence is usually effected by a fluid secreted by the insect, which has the property of softening the threads and gum.

The following paragraphs from Trouvelot explain how this is accomplished:

"*T. polyphemus* is provided with two glands opening into the mouth, which secrete during the last few days of the pupa state, a fluid which is a dissolvent for the gum so firmly uniting the fibres of the cocoon.

"This liquid is composed in great part of bombycic acid. When the insect has accomplished the work of transformation, which is going on under the pupa skin, it manifests a great activity, and soon the chrysalis covering bursts open longitudinally upon the thorax; the head and legs are soon disengaged, and the acid flows from its mouth, wetting the inside of the cocoon. The process of exclusion from the cocoon lasts for as much as half an hour. The insect seems to be instinctively aware that some time is required to dissolve the gum, as it does not make any attempt to open the the fibres and seems to wait with patience this event. When the liquid has fully penetrated the cocoon, the pupa contracts its body, and pressing the hinder end, which is furnished with little hooks against the inside of the cocoon, forcibly extends its body; at the same time the head pushes hard upon the fibres and a little swelling is observed on the outside.

"These contractions and extensions of the body are repeated many times and more fluid is added to soften the gum, until under these efforts the cocoon swells and finally the fibres separate, and

out comes the head of the moth. In an instant the legs are thrust out, and then the whole body appears; not a fibre has been broken, they have only been separated."

The cocoons of *Samia cecropia* and *Callosamia promethea* do not have a gummy coating over the entire interior. In each case the end through which the moth emerges is composed of silken fibres loosely pulled together and not covered with a gummy substance. It is as if each layer of the cocoon was spun into a fringe at this end, the fringes of all layers being bunched together forming a little cone. In the cocoon of *Samia cecropia*, it was possible to push a pencil through this fringe with apparently no effort. The fibres parted readily, it being necessary to break only a few in the extreme outside layer. The same can be said of *C. promethea*'s cocoon.

This condition of affairs evidently enables the emerging insect to escape, without the aid of secretions or cutting apparatus, the struggles evidently helping considerably to enlarge the opening. It is rather strange how few text-books on entomology mention this method of emergence.

SITOWSKI'S NEW ABERRATION OF *COLIAS HYALE* L.

BY P. W. WHITING.

Bussey Institution, Harvard University.

In the *Bulletin de L'Academie des Sciences de Cracovie* for May, 1913, L. Sitowski figures and describes an aberrant form of *Colias hyale* L. to which he gives the name *polonica*. The example, a male, was taken at Radlow in Galizia and appears to be different from any of the forms hitherto described. Besides minor differences of color distinguishing the aberration from the parental form, there is a great extension of the dark border on the upper side of the primaries into the disk, and an entire absence of the border on the upper side of the secondaries. A suffusion of dark scales over the light areas distinguishes the under sides of the wings from the type.

The scales of the wings are strikingly different from the normal, lacking altogether the apical processes and being smoothly rounded off instead. The scent-scales at the bases of the hind wings

are blunt rather than pointed and the striations are parallel to the sides rather than oblique as in the type.

Considerable discussion follows as to the causes which might be supposed to produce an aberration of this type. The hypothesis of Pictet, that one and the same factor may produce different changes of color, is adopted. Melanism and albinism are supposed to be brought about by the same environmental factor acting upon different individuals of the species. As evidence for this view, it is stated that dark forms and light forms occur in the same region, and the aberration *polonica* displays both the melanic and the albinic tendencies in the single individual. The author would seem to assume either that temperature, humidity and light must be constant in any given region or that the life histories of the various members of any species must be so adjusted that they are subject to exactly the same conditions at the same periods of development. It is also not at all clear why the breeding experiments with *Colias* should have been entirely overlooked. Harrison, Main and Frohawk have clearly shown that albinism is a segregating hereditary character in *C. edusa*, and Gerould in very extensive experiments upon *C. philodice* and *eurytheme* has demonstrated the laws of inheritance of albinism with large numbers. Judging also from our knowledge of spotting in general it seems much more probable that the aberrant coloration of *polonica* should be due in part if not wholly to hereditary rather than environmental factors.

EXCHANGE COLUMN.

Wanted, in exchange or for cash, North American Catocala.—Rudolph C. B. Bartsch, 46 Guernsey Street, Roslindale, Mass.

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Will name and return species in certain families of Coleoptera. Buprestidæ especially desired.—C. A. Frost, 26 Pond Street, South Framingham, Mass.

Wanted. Insects from ant-nests, with specimens of the ants, from any part of the world. Will give Coleoptera, Diptera and Hymenoptera from the Western United States.—W. M. Mann, Bussey Institution, Forest Hills, Mass.

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